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A Monthly Popular Journal of Knowledge

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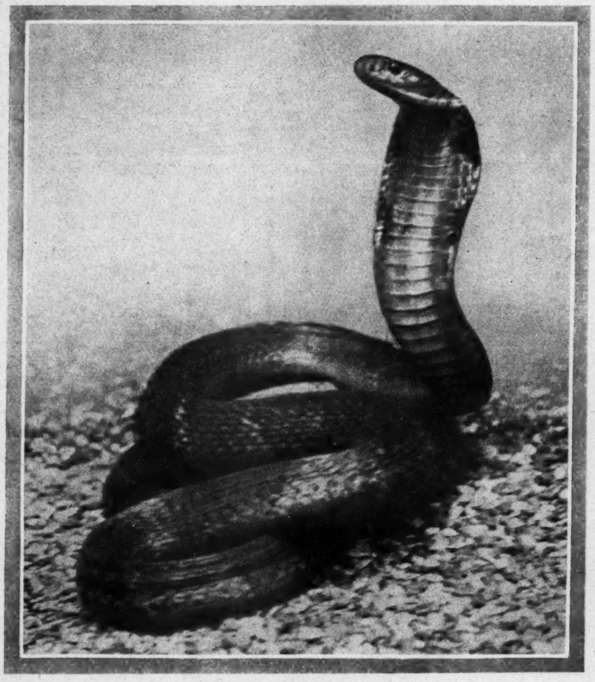

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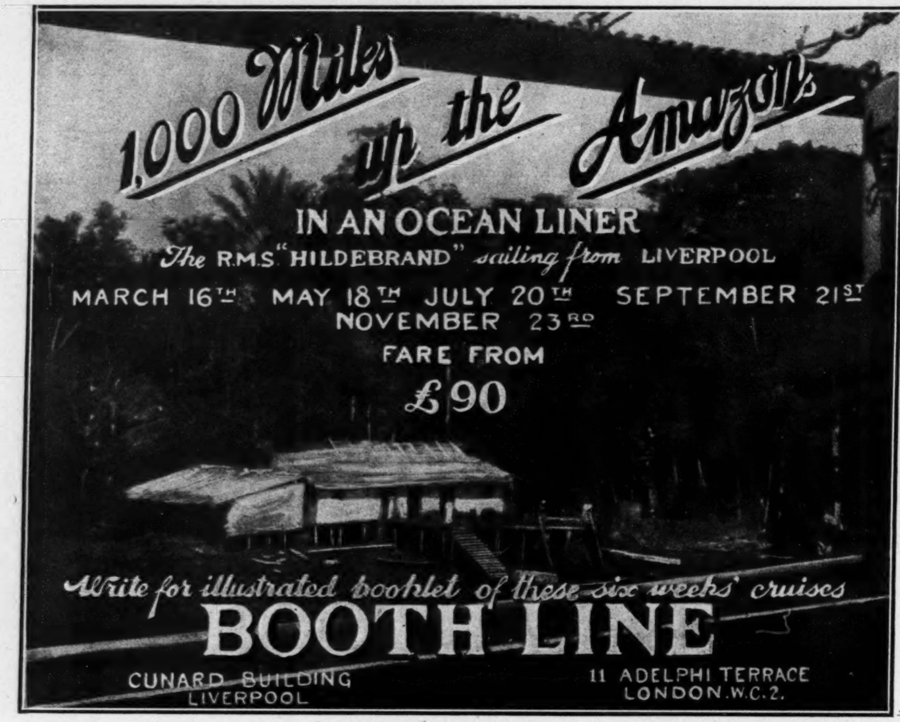

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DISCOVERY

A Monthly Popular Journal of Knowledge

Vol. VI, No. 72. DECEMBER, 1925. PRICE 1s. NET

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Editorial Notes.

THE layman reviewing a quarter of a century's scientific progress sees it as it affects him personally. He translates it into terms of applied science, and if we take stock of our memories there is sound justification for the mythical old lady's complaint that "Science was all very well—but it did creep up on you so." Exact dates for the first adoption of inventions are not easy to fix. There is often a long period between the actual invention and its popularization or even public appearance. If you ask your fellows about their early memories of motoring, or even flying, it is not easy to find agreement about "when a thing first came in." It is even harder to determine when a thing went out. A reference book might tell us when the old smoky steam trains of the Underground gave way to electric traction, but the hansom cab—I do not know if it is quite extinct. I believe that one has been preserved in a museum somewhere, but I have not seen one in the flesh since the devastation of Nash's Regent Street. Twenty-five years ago motor-cars were awe-inspiring novelties, and were not approved of in scientific circles. I have vivid memories of a group of affronted doctors condemning a twelve-horse-power Panhard as unfit for London and only suitable to the straight open roads of France. "Dangerously powerful" they called it. An eminent engineer also gave his opinion that it was a mechanical crime to engage gear wheels in motion. "Unscientific horrors" he called them—they could not last. To-day there are, we are told, some twenty millions of motor vehicles in use, and factories churn out the cheaper brands in thousands a day.

* * * * *

The internal combustion engine was developed and in turn gave us the conquest of the air by heavier-than-air machines. December 17th, 1903, is the date for the Wright brothers' first flight in a motor-propelled aeroplane as distinct from a glider. To-day we are watching the first practical results of the Cierva Auto-gyro, a machine which is perhaps closer to the helicopter than to the aeroplane, but which cannot be classed as either. Experts have been rather disconcerted by its revolutionary design and the special problems of aero-dynamics the scientific analysis of its performance requires. Practical flyers who have seen the machine say that though it may not be theoretically as efficient as the aeroplane it has, to all intents and purposes, solved the problem of almost vertical ascent and landing for low-powered slow-speed machines. The new invention may, when it is more thoroughly understood and out of the experimental stage, make commercial and civilian flying a really practicable proposition of vastly greater use to commerce than it is to-day. Medical science shows astonishing progress. We have only to compare the bill of health for the Boer War with that of the Great War to realize how far we have progressed in the branch of preventive medicine. Inoculation as a protection against typhoid and kindred measures against other diseases are not limited to the state of war. They are the keys to the development of the tropics and the extension of the food-producing area of the globe. Population is increasing and the world's food supplies must be better organized if future generations of humanity are not to be threatened by that old enemy, famine, whose association with pestilence is now seen to be closer than we suspected.

* * * * *

So the practical applications of science to our lives pass in review. Motor-cars, oil fuel, improvements in electric light and power, the telephone system—all these enter into our daily lives. Most of these are not only economies, but time-saving devices. We

have gained speed. In the same way we appear to have accelerated the average mentality. Ideas seem to attain a far swifter general currency to-day than a quarter of a century ago. Matters of suffrage, of unemployment insurance, now commonplace, were then obviously outside practical politics. Birth control was an unwhisperable topic, psycho-analysis would probably not have been heard of even if it had been discovered. To-day we seem to have lost our old vigorous capacity for the condemnation of innovations. It is doubtful if this is due to the spread of elementary education; not entirely proven that it is the effect of the Press. It seems to be due to a change in the thinking classes themselves. They have not so much changed with the times as changed their times. Yet with all our talk of man's achievement and the triumph of our Western civilization, we are always forgetting that ninety per cent of humanity—black, brown, yellow and white—do not think. If they began it does not altogether follow that they would accept our views. After all, the world got on without scientists for many centuries. Nobody seriously denies that science is beneficial, but it would be highly unscientific to assume that it is indispensable except within an organized civilization. Science in Russia appears to have survived the revolution, but instead of the surviving scientific brains dominating the new phase it seems that muscle is still deemed of higher account and that the workers have their own view of the thinkers. It may be unpleasant, but, nevertheless, the bulk of our working classes would probably express the same opinion equally definitely.

* * * * *

It is astonishing how one goes through life without actually seeing things with which one is familiar from textbooks. For years I have heard of Jupiter's moons, of Saturn's rings, and had at least the elements of a bowing acquaintance with our planetary system. It was not until a few weeks ago that I had ever actually looked through a telescope of adequate size. The kindly invitation of the Astronomer Royal, Sir Frank Dyson, F.R.S., gave me the opportunity. Venus, Jupiter, and the star Altair were obligingly forthcoming in spite of adverse weather conditions. The great difficulty was to adapt one's mind to the vast units of measurement. Astronomers may find it easy to build their mental pictures on a scale of light years and to handle infinities as the small change of a rule-of-thumb computation, but the lay mind is left rather exhausted. You seem to see it clearly while it is being explained to you, but afterwards it seems to retreat into the coldness of interstellar space. In the same way we are told that there are two thousand million million molecules in a drop of water, but it is beyond most of us to build up a comforting and satisfactory mental image or idea of this elusive little affair the molecule. Yet science is interpreting matter in terms of molecules and atoms, and multiplying these up to units which we can see and weigh. At the same time science in the astronomical and astro-physical line is calmly working out the geography of the stellar universe by calculations in terms of atoms and, by applying what we know of the infinitesimally small, solving the problems of the stupendously great. I have always wondered what the real work of an observatory was. The main work is the clearing up of the geography and anatomy of the universe. Some stars we know a good deal about, others are less well known. We may know their distance, but we do not know if they are growing brighter or waning. Masses of material existing from past observation are being checked and put into order in the light of modern knowledge. Another affair which is being watched with every refinement of modern observation is the stability of our terrestrial lines of longitude. Are they stable, or is there in accordance with Wegener's theory a slow but measurable western drift ? Time alone will give the answer. In the past all navigation depended on exact chronometers. To-day this represents a dying industry. The broadcast time signals have now superseded the chronometer, and provided a wireless set is available the chronometer can be replaced by any moderately accurate kind of clock. Yet the accuracy of these time signals is dependent on the observatories. Greenwich time as we receive it over the wireless is claimed to be accurate to the tenth of a second. If in practice we were able to eliminate the personal equation we should be able to use it with even greater precision and set our watches to the twentieth of a second. Nevertheless, in practice a variation of a second a week is not likely to affect our precision in catching trains. These terrestrial affairs may be relative crudities, but all come within the routine work of the observatory ; yet when it comes to exact measurement of the transit of a star then the wonderful machinery of accuracy comes into play and an incredible refinement of precision is involved. Endless hours of work are put in reducing the observations to a line of fact and figures. Little by little order is being evolved out of chaos, and every year adds its quota to our knowledge not only of the world we live in, but of the vast universe of which it forms an almost negligible part.

Science and the Alpine Snows.

By Charles W. Domville-Fife.

From Switzerland have come some of the most surprising revelations of the effect of pure sunlight in curing disease. Winter sports may be a relaxation, but at the same time they are justified in their claim that they represent a powerful stimulus to general health.

It has become the custom for thousands of English people, during the months of December and January, to answer the call of the alpine snows. They migrate across France and up on to the roof of Europe, amid the deep snow and hard-frozen ice of a temperate latitude rendered arctic by an altitude of from three-quarters to one mile above sea-level.

The use here of the word "arctic" is perhaps misleading, but it serves to bring us, without unnecessary preamble, to those peculiar conditions, discoveries, and inventions, which have made winter sports above the clouds not only possible but also highly attractive and health-giving.

THE SCHOOL IN THE SUN.
An open-air classroom.

The movement of an army of health and pleasure seekers from the damp and depressing lowlands of Europe to these high altitudes has created a staff of experts whose business is winter sport, and whose knowledge forms the science of the alpine snows.

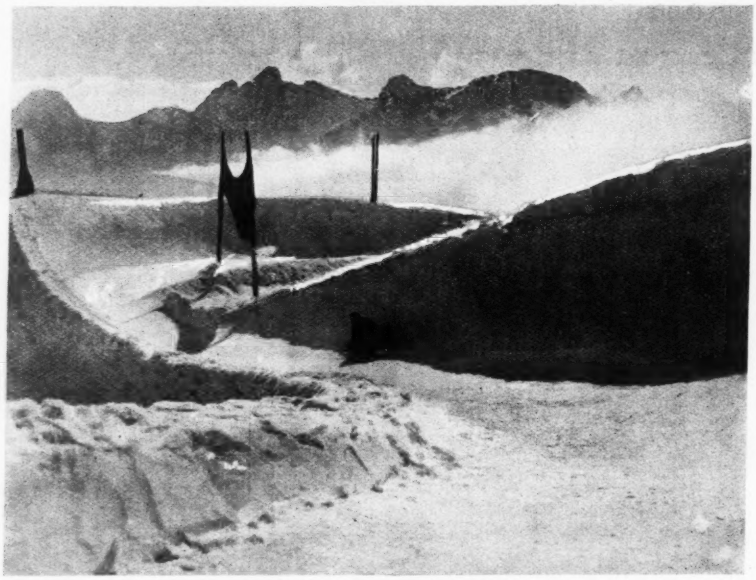
That this science has grown with remarkable rapidity will be apparent from the fact that little over half a century ago all the now famous centres of the High Alps were either tiny wooden villages, hidden away from the world in an unmapped wilderness of rock and snow, or barren tablelands inhabited only by chamois, the ibex, the marmot and the eagle. They were inaccessible during the period of deep snow-fall, and even the ubiquitous ski-er was unknown.

The winter climate of these lofty, snow-covered rocks and glaciers was considered by the few who had studied the region to be far too rigorous for either the health or pleasure of lowland folk. How far the coming of knowledge and skill has changed all this will be apparent from even a short visit to, or a superficial knowledge of, such places as, St. Moritz, Mürren, Wengen, Villars, and, perhaps even more illustrative of the point, the great sanatoria of Leysin, Davos, Arosa, Adelboden and Montana, in which live, winter and summer, over 20,000 invalids from all parts of the world.

The first discovery in the science of the alpine snows was made by Dr. Alexander Spengler, a political refugee who went, as district doctor, to a small village in the Grisons in the year 1853. This unheard-of and roadless collection of crude wooden chalets was called Davos.

In this valley, about a mile above sea-level, and surrounded by more lofty peaks clad in eternal snow and ice, the young doctor discovered that pulmonary complaints—so prevalent in the damp lowlands from which he had come—were almost unknown. He started a campaign in distant lands and cities, advocating the sending of invalids to Davos, so that they might benefit from a climate which made residents unusually healthy. He went even further, and advised these invalids to spend not only the summer but also the winter months in this rigorous climate.

Like most medical reformers, he was ridiculed at first and then violently attacked. His theories



A DIFFICULT PIECE OF SNOW-ENGINEERING.
A double corner on a bobsleigh run above the clouds.

were pronounced not only absurd, but positively criminal. However, Dr. Spengler persevered, and a wonderful statue now stands in Davos to his memory. A few brave pioneers—and being invalids they certainly were brave—ventured into what was then an alpine wilderness. Nearly all of them were cured, but several years elapsed and those who came for health remained for sport.

Among these early pioneers was an English man of letters, John Addington Symonds, who immediately recognized the possibilities of the up to then unthought-of winter sports. He collected round him at a little place called Klosters a party of enthusiasts, organized crude toboggan races, and made known the beauties of the alpine winter throughout Europe by his writings. In this way not only was a new fascination added to the alpine scenery, but a national industry—for such has winter sport become—was slowly but surely inaugurated.

Discovery of Sport.

The first skating rink in the Alps was opened at Davos by English visitors in 1876-77; tobogganing on an ice-track was started at St. Moritz in 1884-85. This was the beginning of that wonderful piece of snow-engineering the Cresta Run. It is, however, unnecessary to follow the history of winter sports, the purpose of this article being to give an outline of the application of scientific principles to these virgin snow-fields and to briefly describe some of the discoveries made.

There can be little doubt that the most far-reaching and at the same time, perhaps, the most simple achievement was the unveiling by careful study and observation of the mystery of alpine sunlight.

Winter Sun.

It is difficult to imagine snow and ice all around, and yet a hot sun pouring down its life-giving rays all day and most days during the long alpine winter. Yet such is the case, and one is tempted to probe the ice of skating rink and bobsleigh run in order to make sure that it is not melting rapidly under the fierce rays, which are bronzing the human skin and enabling exercise to be enjoyed in the open without overcoat or wrap.

This is not so inexplicable as it sounds. A thermometer exposed full to the midday sun, during the months of December, January, and February, often rises to 105° F., while a similar exposure on the French or Italian Riviera would be most unlikely to send the mercury higher than 70·80 degrees. The sun's rays are reflected upwards from glittering ice and snow-field. The shade temperature on an alpine summit at the same hour of the day will, however, almost certainly be well below freezing point, and it is this frosty sunshine, to use an anachronism, which produces the extremely dry, tonic effect of the atmosphere.

With the setting of the sun, however, the thermometer tells a different tale, and many degrees of frost are registered during the long hours of darkness. In explanation of the beneficent influence of the sun's rays at high altitudes Dr. Rollier, one of the foremost exponents of the sun cure, who has spent many years at Leysin—4,500 feet up in the heart of the Vaudois Alps—has said that: "The solar rays only reach low-lying lands after passing through the whole thickness of the atmosphere, and the air of the plains is frequently saturated with moisture; that of the cities is, furthermore, loaded with dust, smoke and micro-organisms. This layer, which constitutes what a physician has picturesquely described as ' atmospheric

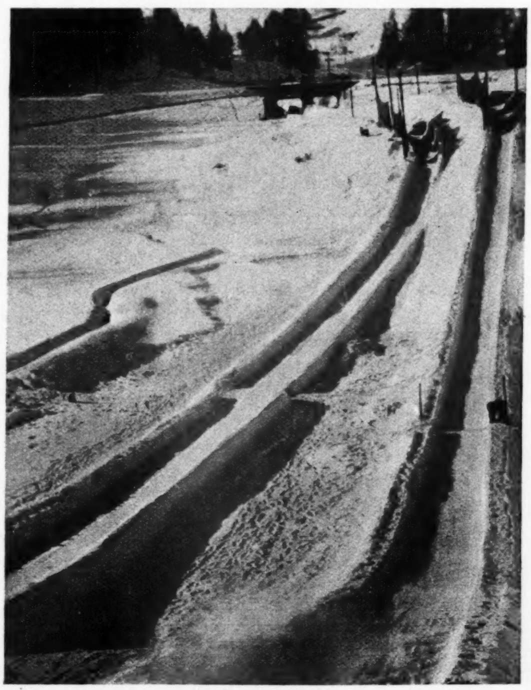
slime' forms a screen, which prevents a great part of the useful solar rays from reaching the ground. That is why, in winter, the climate of high altitudes is usually more agreeable than that of the plains."

Here then we have the secret of the alpine sunlight. Before these climatic and atmospheric discoveries could be put to practical use, however, it was necessary to overcome many obstacles. Foremost among these was the problem of transport from the lowlands to the snows.

Exactly what this entailed will, perhaps, be more fully realized if a brief description is given here of how the great difficulty was overcome by the Rhaetian Bahn, running from Coire in the lowlands of south-western Switzerland up to the lofty valleys of the Grisons, 6,000 feet above sea-level.

Engineering Triumph.

Although this line is only 173 miles in total length, the constructional cost exceeded six millions sterling. This huge expense is, however, not to be wondered at when it is considered that in this comparatively short distance the electrically-operated locomotives climb nearly 5,000 feet and run through 81 tunnels, over 407 bridges, round 23 loop lines, through 7 loop tunnels ($2\frac{1}{2}$ miles long), past 40 miles of avalanche defences, under 28 avalanche sheds, and through one of the highest tunnels in Europe, the Albula, which is elevated 5,981 feet and is nearly 11 miles in length. One of the bridges on this system—the Solis—is 543 feet across and spans a chasm 291 feet deep.



A WONDERFUL PIECE OF SNOW-ENGINEERING:
The famous Cresta Run, St. Moritz.

In winter the snow-drifts along the exposed sections of this line are often from ten to twenty feet deep, and the track running through them has to be cleared by rotary and wedge snow-ploughs. The electric current necessary to operate this system is obtained from turbines driven by a number of local waterfalls.

Although this system ends at St. Moritz and Pontresina, about 5,960 feet above sea-level, another line carries on from this point into the glacier world of the Bernina Range, reaching a height of 7,402 feet on the summit of the pass between Switzerland and Italy, and a cable system, the Muottas Murail, reaches even higher altitudes, 8,058 feet. The drifts after a heavy fall of snow along these systems sometimes exceed thirty feet in depth.

The history of all alpine winter resorts is the story of these marvellous mountain railways—often constructed one above the other, from sea-level to regions of perpetual snow. Such lines as the Jungfrau, which reaches upwards through the clouds for nearly 12,000 feet, are among the scientific wonders of the age. They could not have been successfully built or maintained if it had not been for various discoveries made in the methods for placing a check upon the tendency of bare and steep mountain slopes to deluge the valleys with their enormous burdens of snow, in the form of dangerous and destructive avalanches, on the slightest provocation from the sun and warm Mediterranean winds which find their way through the passes.

Afforestation.

It soon became obvious that if the High Alps were to be rendered safe for human habitation and travel, some less costly and more general method of avalanche defence must be found than snow-sheds, concrete walls, lines of stakes connected by wire entanglements and artificial ledges. Those places which were exposed to avalanches, and where such would endanger the mountain resorts or their lines of communication, were consequently planted with pine trees. Nature soon increased these plantations to vast mountain forests, the trees creeping steadily upwards to the timber line, which varies from 6,000 to 8,000 feet. Above this altitude no winter sport centre can, there-

fore, be built with safety in the neighbourhood of a steep slope.

When a railway to the summit of the Jungfrau was first suggested, one of the seemingly insuperable obstacles to the construction of such a line was the frequency and danger of avalanches on the bare mountain side above timber line. Here, again, Swiss skill and enterprise solved the problem. Up to 8,000 feet the line skirts the slope, and then dives into a tunnel which bores into the core of the mountain, and from this it does not emerge even when the summit station—the Jungfraujock—is reached at 11,800 feet. The track, the wayside stations, the restaurants, the post offices and, finally, the most lofty hotel in feet deep, in the heart of the great mountain range.

Having overcome all the major difficulties of transport from the lowlands to the alpine heights, there remained the minor task of building luxurious centrally-heated hotels on these lofty plateaux, and of harnessing the snow and frost to provide sporting facilities for the guests in these residences above the clouds.

Snow Preservation.

For constructing the hotels and to provide the fuel for the making of the electric current, where water-power was not available, wood from the forests planted in previous years as a defence against avalanches

AN ARTIFICIAL ICE-CAVE.
One of the galleries cut into the heart of the Mirteratsch Glacier. It is illuminated by electric light.

Europe are all subterranean caverns. Galleries lead from the central tunnel to the rock-hewn apartments and also to the outside face of the mountain. The openings at the end of these galleries are, however, closed with thick glass and protected by iron doors, like the portholes of a ship, so as to prevent the entry of the icy wind and driving snow which often swirl round the mountain even in summer time.

Avalanche-proof.

The artificial cavern at the summit station contains one of the most lofty hotels in the world, from which a gallery 400 feet long leads up to the outside realm of snow and ice. It is, therefore, possible for glaciers and avalanches to move and roll harmlessly over the line and its stations, which are safe, hundreds of

was largely used. By ingenious snow-engineering, toboggan runs and skating rinks were provided.

Here the enemy of success was the midday sun—that which provided these winter resorts with one of their principal climatic advantages. It either destroyed these snow-works or else rendered the carefully-planned curves, embankments and inclines too thin for safety. Where allowance in size and thickness could not be made for the daily ravages of the sun, huge canvas screens had to be erected wherever the destroying rays fell upon a dangerous point during the hours of 11.30 a.m. to 2 p.m. It was discovered that before and after these times the frost was, generally, more potent than the sun.

The maintenance throughout the winter of a perfect surface on the ice skating rinks provided a small

crop of problems. Nothing is more fascinating to the lover of winter sports than the sunny, scintillating mornings spent skating and waltzing to the tunes of the orchestra in the still, frosty air. For this reason it was considered inadvisable to place these rinks in the shadow, but the sun's rays weakened the surface of the ice every day, so that it became necessary to clear the rinks of skaters between 12.30 a.m. and 1.30 p.m. To enable this to be done the lunch hour was advanced so as to cover this period and, in addition, huge ice-chisels were improvised to scrape off the worn and weakened surface each midday.

In order to prevent the rapid thinning of the ice, caused by this daily planing of its surface, every rink has to be sprayed with water during the night or early morning when the frost is sharpest. And this is not the only difficulty. A night of thick snow means the clearing of two or three feet of this heavy, white, frozen water from acres of ice. Two or three days of blizzard means that the rinks have literally to be dug out, the village streets cleared and the miles of toboggan and lüge runs almost rebuilt.

The Rescue Service.

With the introduction into the High Alps of the Norwegian ski in the year 1902-3, enabling thousands of inexperienced mountaineers to roam far and wide over treacherous snow-field and glacier, a new difficulty presented itself. If a large number of accidents were to be avoided and the winter sports saved from getting a bad name, then the whole upper world of rock, ice, and snow would have to be, at least superficially, surveyed and charted.

In this great scientific work both the Swiss Alpine Club and the Swiss Army took an active part. The former established a corps of qualified guides, whose distinctive badge is a symbol of reliability and safety. A large number of fully-provisioned huts were built in difficult and dangerous places, usually at an elevation of from 7,000 to 9,000 feet. Rescue and Red Cross parties were established at almost every alpine centre, and these were linked up by telephone. A system of distress signals was devised, and an intelligence service organized. It is this latter department which is responsible for the notices, occasionally displayed in all winter sports hotels, forbidding ski-expeditions and the employment of guides when the local snow and ice conditions are treacherous.

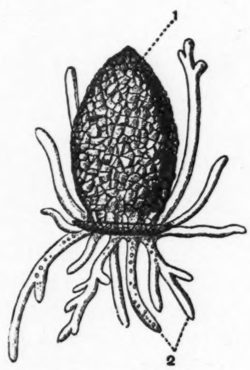
Without attempting the long and difficult task of describing the wonderful organization of the purely health centres of the High Alps, it is necessary for the sake of completeness to mention the great sanatoria of Leysin, which lofty little town is entirely devoted to the war against tuberculosis in its many forms. Near to this place is the now famous "School in the Sun," where children in the convalescent stage spend the sunny hours of both winter and summer playing, resting, and working in a state of nudity.

The problems which have been solved, the discoveries made, the constructional achievements, and all that has been done to cause the High Alps to become the winter playground of Europe, is the work of science amid the great snows.

RHIZOPODA WITH SHELLS.

(Continued from page 477).

In one species at least of *Difflugia* as time goes on many of the nuclei disappear and the protoplasm undergoes a process of encystment. In the spring the cyst bursts and gives issue to a number of new nucleate secondary cysts, but, as Hamlet says, "the rest is silence." We don't know what becomes of them. Probably they grow up into new *Difflugias*. In *D. ursulator* again in the autumn the protoplasm of one specimen will pass over into the shell of another and fuse with its neighbour, and very frequently the two shells adhere to one another so that we have a full shell containing the fused individuals attached to an empty shell. This double shell arrangement is by no means uncommon. As a rule in this genus the shells are flask-shaped, and some of the largest varieties may reach the length of half a mm. Occasionally the little animal is coloured by minute particles of yellow or blue fat or oil. There is a good deal still to be made out about the life history of these interesting forms, but the difficulty of investigation is greatly increased by the fact that the shells are in nearly all cases opaque, at any rate in the latest stages of the animal's life.



DIFFLUGIA URCEOLATA, x100.
(*After Leidy.*)
1. Shell composed of particles of sand containing body of the animal. 2. Pseudopodia.

A new element with the atomic number 75 is reported as discovered at Prague by Dr. I. Heyrowsky of the Czech University. It was isolated from a manganese salt, and is provisionally named "Bohemium."

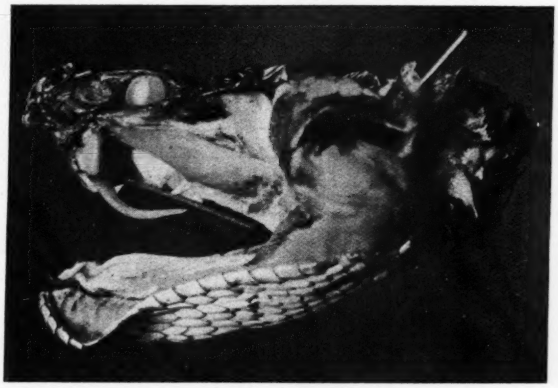
long, and can be erected or folded back against the roof of the mouth. It is quite impossible to avoid a full dose of poison if bitten. The venom itself is of an entirely different kind, which acts upon the blood, with fatal results in the case of the larger species. First-aid for snake-bite consists of immediate ligatures to cut the bitten part off from the circulation, and then the bite should be opened up with a knife, and as much blood and venom as possible squeezed out. Only after this has been done is it wise to move the patient or allow any whisky or other stimulant to be drunk, for the great thing to avoid is stimulation of the pulse. In most tropical countries where dangerous snakes are common, serum can be afterwards administered by a doctor, and very encouraging results are being obtained by its use.

Blind-burrowing Species of Group 1.

There are two families of these very degenerate snakes, all very small and covered with roundish, polished scales. Their eyes are either absent altogether, or so vestigial as to be mere dots indicated in the ocular scale. Frequently the head and tail are so much alike that it is necessary to make a careful examination before one can be certain which is which. All the members of this group live underground lives and feed upon worms. They are rarely seen, except when they are accidentally dug up.

The Constrictors.

These form a natural family of very powerful snakes, all of which kill their prey by crushing it in their coils before eating it. A typical example is the Reticulated Python of the East, the largest of present-day species, which reaches over thirty feet in length. Like the majority of true pythons, it is difficult to tame. Quite small ones bite savagely, and the twenty-five foot specimen now living in the Zoo is so dangerous that it has to be shut off behind an iron shutter before its cage can be cleaned. The Indian Python is less irritable, and the most gentle are the beautiful African Royal, and the Australian Diamond Python or "carpet" snake.



THE POISON APPARATUS OF A RATTLESNAKE.
The temporal muscles are dissected away and pinned back to expose the venom gland, its duct and the partially erected fang.

The boas are separated from the pythons in a sub-family of their own. Amongst them the South American anaconda is placed, another giant among snakes, reaching thirty feet. It is extraordinary how powerful these big constrictors are; they can crush and swallow full-sized pigs, antelope, and deer. Specimens of about ten feet long require several men to hold them safely, and a twenty-foot one needs ten men or more. Although their bite is harmless in the sense that it is not venomous, all the pythons and boas give a severe tearing bite, and when they have got hold it is very difficult to extricate oneself from their long curved teeth. The anaconda is a river snake, and is a very powerful swimmer and able to remain submerged for a long time. Usually, however, it remains in the water with just the tip of its snout above, watching for its prey.

Another native of South America is the common *Boa Constrictor*, one of the most beautiful of all snakes. Young specimens become very tame, and make charming pets. They live in trees, and feed upon birds and mammals, hunting chiefly at night. With the exception of the Green Tree-boa, which is vivid emerald green patterned with ivory, the common boa is the most beautiful of the constrictors. The ground colour is chestnut shading, to coral on the tail, and on this is woven a most complicated pattern in ivory, chocolate, black and Indian red, progressively brightening on the tail which is all ivory, black, and red. One which I kept as a pet in my office was very intelligent, and an adept at hiding itself. A favourite retreat was a row of books along the back of my desk. It found that by pushing out the first, and insinuating its nose, it could push each book forward and lie along the back of them, leaving its tail in place of the displaced book and watching my visitors from the other end.

Although most of the boas come from tropical America, a few are found in the Old World, particularly in Madagascar. There are also some degenerate burrowing species, desert forms only about two feet in length, found from Egypt across to India.

Snakes.

By Joan B. Proctor, F.L.S., F.Z.S.

Curator of Reptiles at the Zoological Gardens.

Illustrated with Photographs by F. W. Bond, F.Z.S.

The author is on perfectly good terms with snakes and pleads for a better knowledge of them. They are apparently misunderstood creatures.

THE dislike which most people have for snakes is due chiefly to the mass of superstitions and popular fallacies in circulation about them. The average person will tell you that snakes are cold, slimy, creepy things which sting you with their venomous forked tongues. But snakes are warm, dry, swift and graceful, and their fluttering tongues are as harmless as a cat's whiskers. It is really a pity that they should be so much misunderstood. Almost any person who is shown a snake under proper conditions, or who has kept one as a pet, becomes fascinated by its beauty and soon loses the fear born of ignorance.

Classification.

There are over two thousand kinds of snakes, most of them tropical, for the majority rely on the heat of the sun to hatch their eggs. In England the common viper gets over this by retaining her eggs until they hatch, so that the baby vipers are born fully formed and able to take care of themselves. The grass-snake makes use of the heat generated by rotting vegetation, and that is why their eggs are so frequently found in manure heaps and the stacks of rotting weeds along river banks.

All snakes are cold-blooded, that is to say, their blood-heat is dependent upon the temperature of their surroundings. They have no limbs, although the pythons and two or three other families have vestiges of them. The two halves of their lower jaw are connected together at the chin, and also to the upper jaw, with elastic ligaments instead of bony articulations, and this last characteristic alone may be used to distinguish them from the legless lizards which superficially resemble them in many ways. Many other characters—such as the absence of ears and movable eyelids—are usually included in a definition. The zoologist places snakes in an order called Ophidia, and further subdivides this into families, genera, species, and varieties. The characters which are used in this scheme of classification require a detailed knowledge of their comparative anatomy, and particularly of their teeth, of which there are an enormous number of different patterns.

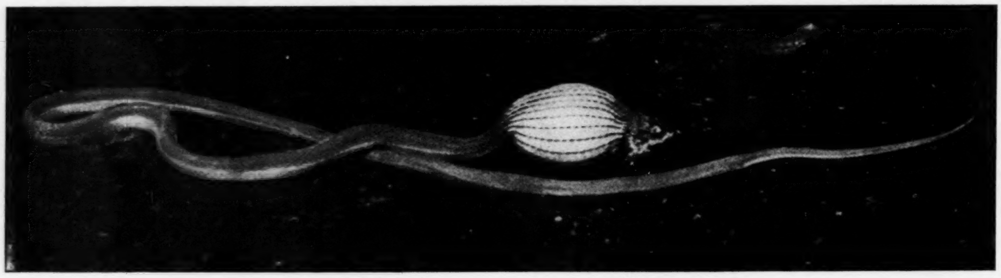
In an outline of this kind they are best reviewed in groups, as follows:—

1. Blind burrowing species.
2. Constrictors.
3. Harmless solid-fanged species.
4. Slightly poisonous back-fanged species.
5. Dangerous front-fanged species.
6. Vipers.

In all the groups excepting 1, there is a great range of variation in form and habitat, including tree-snakes, water-snakes, ground- and burrowing-snakes, of both nocturnal and diurnal habits and every grade of temperament. Some of the most harmless to look at are the most spiteful and venomous, and some really evil-looking ones make charming pets.

The Poison Apparatus.

They all feed upon live prey, which they hunt and kill in various different ways. The venomous species inflict a poisoned bite which either kills or paralyses the victim. The fangs with which the poison is injected are longer than the solid teeth, curved, and either grooved or tubular. The poison is secreted in a gland at the side of the back of the head, and, when certain muscles are used in the action of biting, it is forced from the gland down a duct leading to the fangs and on into the wound caused by the bite. In fact, the apparatus works very much like a hypodermic syringe for the injection of venom. In the back-fanged species these fangs are at the back of all the solid teeth, and they are less highly developed and only grooved, so that there is less risk from a bite from these, for the venom does not always get injected as the teeth are so far back in the mouth. In the front-fanged group—to which the cobras, tiger-snakes, and sea-snakes belong—the fangs are the first of the series, and in many cases the other teeth are small and few in number. A bite from almost any of these snakes may be expected to have fatal results, the venom paralysing the respiratory apparatus and the nerves of the heart. In the vipers the front-fang type of apparatus is carried to a still more perfect stage. The fangs are always tubular, enormously



THE EGG-EATING SNAKE.
This specimen has just swallowed a hen's egg whole, and is about to saw through the shell with its gullet " teeth."

Next we have the harmless solid-fanged snakes.

The species thus grouped together belong to several distinct families and sub-families, and comprise the vast majority of the whole order. It is, however, only possible to deal with a few typical species here.

One of the most interesting is the Egg-eating Snake, unique in possessing " teeth " down the back of its throat with which it saws through the shells of eggs which it has first swallowed whole. These are not true teeth, but processes from the vertebrae of the neck which penetrate the gullet and act as such. It is an amazing sight to watch an Egg-eater eating a hen's egg, for the snake is small and its head is much less than half the diameter of an egg. Nevertheless, with the help of the elastic ligaments attaching the lower jaws (both to each other and to the skull), they are able to stretch their mouths to such an amazing extent, that the egg is swallowed whole and uncracked. When it has been dealt with in the gullet the shell, in the form of an elongated pellet, is thrown up, its contents having been first passed into the stomach.

The North American Hog-nosed Snake is another very attractive species, although, unfortunately, they do not do well in captivity because they are usually badly infected with worms. These snakes are thick-set and viper-like in appearance, the end of the snout turning up abruptly into a soft horn like that of the Rhinoceros Viper. The back is strongly marked in rich shades of brown and black, and the pupil of the eye is like that of a cat. In spite of a distinctly evil appearance, they are the gentlest of snakes, and will not bite however roughly they are handled. They protest by flattening the body, especially the neck, and assuming a threatening attitude with loud hisses. If this does not answer they give an excellent imitation of an epileptic fit, and turn over on their backs as though dead. They hunt at night, and feed upon toads.

North America is rich in harmless snakes, many of which live well in captivity and are easy to obtain. There are the Corn snakes, which are a rich chestnut red colour; the striped Chicken and Black Pilot snakes, which are two varieties of one species; the gentle King snake with its chained markings, the racers; and any number of others.

Parallelism is common in reptiles, and amongst these solid-toothed forms there are the " false " coral snakes, " false " moccasins, and many viper-like and cobra-like species, as well as tree- and water-snakes resembling poison-fanged cousins. This is not necessarily due to mimicry, for some of the most perfect parallels do not inhabit the same continent; it is due to genuinely parallel lines of development from separate stocks.

Back-fanged Snakes.

The majority of these belong to one sub-family, and in their range of variation of form and temperament they are very similar to the solid-fanged families. The most noteworthy of this group is the South African Boomslang or tree-snake, which lately won for itself the distinction of nearly killing a well-known collector. It had always been supposed that none of these snakes was very poisonous, but this species proved to be quite as poisonous as many of the vipers.

The most beautiful species are the long-nosed tree-snakes found in South America, Africa, and India, most of which are emerald green, and very slender. Another, the Ornamental Tree-snake of the East, is also known as the flying-snake, because it is able to draw its under-surface in against its back, and *vol plane* from tree to tree, like a glider. It is certainly ornamental, for it is yellow-green, vermiculated with black and spotted with crimson.

Front-fanged Snakes.

These belong to two sub-families, the sea-snakes and the cobra sub-family. The Sea-snakes have nothing to

A WHITE SPECIMEN OF THE INDIAN COBRA.
This beautiful albino has red eyes and a pale pink tongue. It belongs to Mr. Roberts of Delhi, but has lived at the Zoo for the past year on loan. The photo was taken out of doors at a six ft. range.

do with the legendary sea serpent, but are ordinary very poisonous snakes which live in the sea or in estuaries. Nearly all of them come from the Indian Ocean and the coasts of Indo-Australasia. All Sea-snakes have oar-like tails, and another interesting thing about them is that whereas ordinary snakes have one notch in the upper lip through which the tongue is ejected without opening the mouth, Sea-snakes have two, and only the bifid portion of the tongue is protruded, each half through its own notch. As a rule none of them grows very big, but I have seen one about eight feet long.

Of the cobra group, the most well-known are the coral snakes of tropical America, the Cobras and Mambas of Africa, the Cobras, Hamadryads and Kraits of the Indian region, and the Tiger and Black snakes of Australia. All cause an enormous number of deaths annually through snake-bite, especially in places where coolies work with bare feet, and therefore stand no chance if they should tread upon one.

Few people realize that cobras are much more active at night, and are often sleepy in the daytime when they are also distinctly short-sighted. It is a comparatively easy thing to "play" a cobra in the daylight, if one is accustomed to their ways, and many so-called snake charmers are merely very quick and clever with their cobras, thoroughly understanding how to bewilder them, and keep them "dancing" with spread hood, and at the same time avoiding being struck at, without appearing to do so. There are, of course, natives who are immune to the venom, and these are able to give a really exciting display, because they run no risk from the venom, and can therefore allow themselves to be bitten freely.

THE HORNED ASP OF EGYPT.

The Hamadryad or king cobra is the most to be feared of all the poisonous snakes. To begin with, it is very savage and irritable, and will deliberately attack a man without provocation; but this is not all: instead of being a little stupid like the cobra, or rather sluggish like some of the vipers, it is so swift and sure in its movements that the average man stands no chance against it whatever. Added to this, a single drop of its poison might be sufficient to kill a man, but eight or nine drops is the amount which it is likely to inject into a bite. Cobras themselves, and other snakes, have reason to fear it as much as man, for it preys entirely upon other snakes, which it has no trouble in catching owing to its superior speed. The specimen which was presented alive to H.R.H. the Prince of Wales during his Indian tour, and which has been living in the reptile house at the Zoo ever since*, eats three or four grass-snakes a week in the

* This snake has died suddenly since this was written.—J.B.P.

summer, and would do so in the winter too if it were allowed; as it is difficult to keep up its larder in winter it is rationed to two a week, but even on this strictly regulated diet it is growing enormously, and is now nearly nine feet long. It is now necessary to turn it through a trap-door into another cage, before the door of its own can be opened with safety.

The Vipers.

The vipers also fall into two natural sub-families: the Old World true vipers, and the pit-vipers, so-called because of a deep sensory pit which is always present between the nostril and the eye.

The true vipers range from the small adders and asps of Europe and North Africa, to the dreaded Russel's viper of India and the large puff-adders of tropical Africa. The most beautiful of them all is the Gaboon viper, one of the true puff-adders. This is a very heavily-built snake, with a perfectly triangular head and short tail. It is patterned with the brilliancy of a turkey carpet in a bold design of wine-red black, various rufous browns, and ivory. Perhaps its cousin the Rhinoceros-horned viper is even more dangerous looking. Another well-known species is the Horned Asp of Egypt, which was chosen by Cleopatra as an artistic mode of suicide. Evidently the deluded queen did not know how extremely painful is death by viper-poisoning, or how unromantic the symptoms, and how disfiguring the resulting hemorrhages! The businesslike modern Egyptians make money by selling sham Horned Asps to collectors, patiently made by sticking the spines from sea-urchins through the "eyebrows" of the common unhorned asp. One such specimen was so neatly prepared that it was mistaken for a species new to science by a zoologist who should have known better.

The pit-vipers divide naturally into two groups, those with rattles and those without. To the latter belong the Bushmaster, Moccasin and the Fer-de-lance, all of which are the giants of the viper family, attaining six feet or more. In the old days planters introduced the Fer-de-lance into the West Indies to stop slaves from running away. No slave would face life in hiding in the sugar plantations with death by the bite of these snakes as an almost certain end. The snake, however, became such a pest that the mongoose was introduced to exterminate it. Now the mongoose has become worse than the rabbit in Australia, and efforts are being made to get rid of it.

There are many species of rattle-snake, and they cause a great number of deaths from snake-bite annually in the United States. The rattle itself is composed of loose pieces of horn attached to the end of the tail-vertebrae. The loud buzz which it produces is made by an intense vibration of the tail which occurs automatically when the snake is alarmed or otherwise excited. It is not only rattlers which do this; many species of snake will do so when upset, even though they have no rattle, and if they happen to be amongst dry leaves the buzz can be plainly heard. Besides many harmless snakes, I recently saw a Hamadryad doing it.

There are large rattle-snakes and also pygmy species. Most of them live in rocky homes, or the burrows made by other animals. One of the prairie forms shares the burrow of the prairie marmot, the two living in harmony together. Probably the snake eats a baby marmot occasionally when its parents are out!

It would be far easier to write a three-volume book than an article on snakes, for they are so varied and so interesting, both in their forms and in their temperaments and habits. Perhaps this is enough to show that at any rate they are not dull, creepy-crawly things as most people like to believe.

THE RONTGEN SOCIETY. 1925—1926.

THE meetings of the Rontgen Society will be held in The British Institute of Radiology, 32 Welbeck Street, London, W.1, on the following Tuesday evenings at 8.15 p.m.:—1st December, 1925; 5th January, 2nd February, 2nd March, 30th March, 4th May, and 1st June, 1926.

(*Continued from page 463.*)

GREAT BRITAIN'S MEDICAL RESEARCH INSTITUTE.

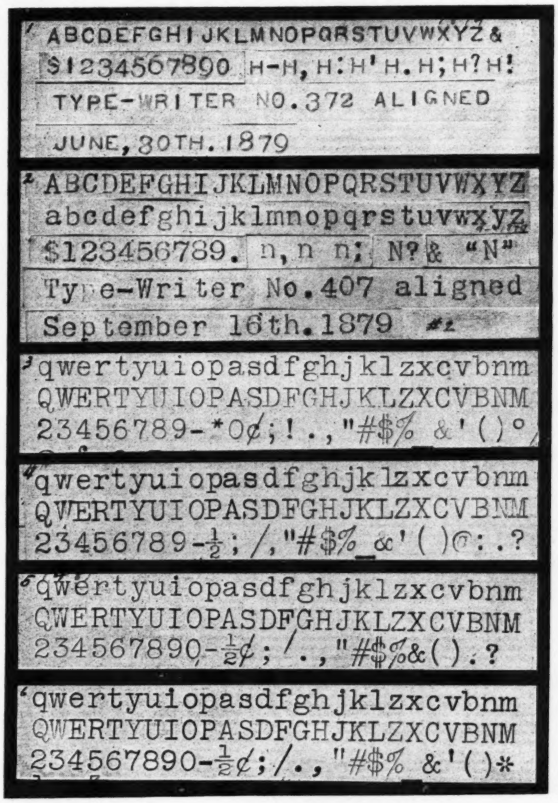
is some claim for the view put forward recently by a scientific essayist that conditions in Great Britain are most favourable to the success of pure research. While the restrictions imposed by relatively small financial means are sufficient to discourage any but first-rate workers, they do not preclude the collaboration of men who enter the scientific world by unconventional paths, marked out by their own pioneering ability. They seem to furnish a form of selection which is often lacking where funds are most abundant, and to assure the public whose money is so admirably used of the services of men of outstanding brilliance, whose achievements ultimately benefit, not merely their own countrymen, but the whole of humanity.

Typewriting as Evidence.

By Albert S. Osborn, New York, U.S.A.*

When the authenticity of typewritten documents is questioned, expert scientific evidence is often necessary. The author, who is an official examiner of questioned documents to the State of New York, indicates some of the methods used.

The great modern typewriting industry began at Ilion, N.Y., U.S.A., in the year 1874. At this time the Remington Arms Company took the crude working model of a machine that would write and began to manufacture it for public sale. Progress was very slow, and not till 1879, when the shift-key principle with other improvements were incorporated, did the machine begin to attract attention. From that time to the present day writing by machinery has become more and more popular, until nearly all important business documents are typewritten and in many fields the writing machine is more and more coming into use.



1 and 2. STAGES IN THE HISTORY OF THE ROYAL TYPEWRITER.
3 to 6. STAGES IN THE HISTORY OF THE REMINGTON TYPEWRITER.

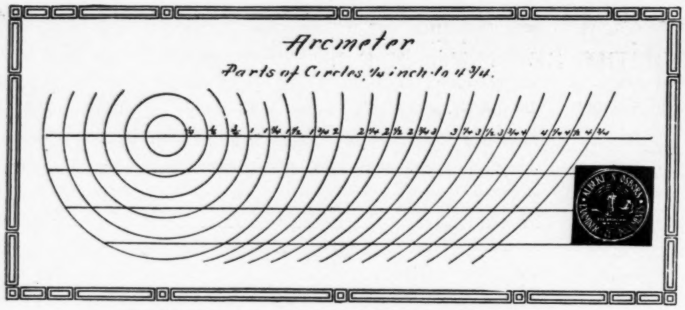
Individuality.

It was early assumed that it would be impossible to identify the typewriting of any particular machine from the work of other machines of the same kind, and in the course of time the machine began to be used here and there as an ally of crime or an assistant in fraud. There still are many persons, many of them in the typewriter business, who do not know that typewriting can be identified. It is related that the Sultan of Turkey in the early days refused to admit the writing machine into his realm for the reason that it apparently afforded a means of preparing seditious writings with no opportunity of discovering the authors. It gradually became known, however, that each writing machine developed an individuality, sometimes even more definite and positive than the individuality in handwriting, and also that typewriting often possessed a date significance that might be very important.

Types.

This individuality and the differences in the type of different dates and on different machines develop in many ways. In the first place the typewriting industry created a demand for new letter designs. As is well known, typewriting is produced by moving the paper a certain distance for each character, and a mechanical requirement of machine writing was therefore that all letters must occupy the same space, which on the ordinary machine is ten to the inch. As is well known, the space in typewriting for a narrow small "i" is the same as for the wide capital "M." This necessity for new designs of letters gave an opportunity to letter engravers, and for many years the changing ideas as to the most desirable forms of letters led to changes which have been highly important in connexion with typewriting identification, and especially the determination of the date of a typewriting. These changes have actually continued down to the present day. Some leading machines

* Author of "Questioned Documents," 1910; "The Problem of Proof," 1922.



AN INSTRUMENT ON GLASS WHICH MEASURES THE DEGREE OF CURVATURE OF CONNECTING LINES IN HANDWRITING.

have made radical changes within the year, by means of which the date after which a particular document must have been written on a certain kind of typewriter can positively be determined.

The individuality of a particular machine is shown in five principal ways. The first of these is the design, style, proportions and size of the particular type which identifies a particular font or style of type on a certain kind of machine.

Specific Qualities.

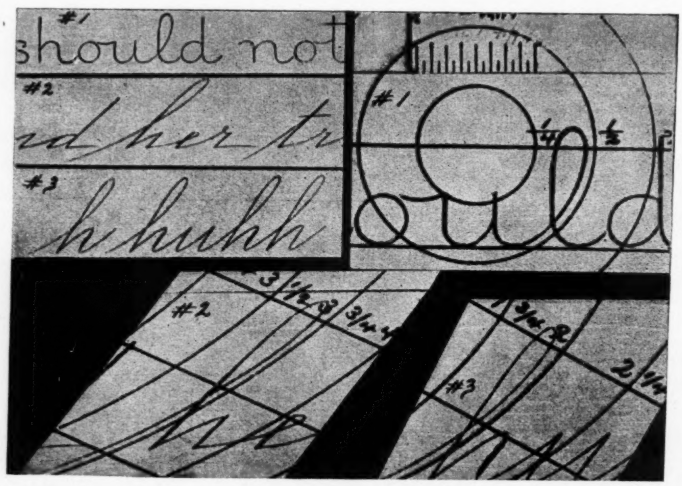
The second identifying quality is the lack of uniformity in alignment of the several characters in relation to each other. Many are surprised to know that typewritten letters are in line vertically as well as horizontally, and when a machine writes perfectly each character occupies the centre of a ten to the inch space horizontally, and a six to the inch space vertically in single spacing on the ordinary machine. Any habitual divergence in alignment of any character is, of course, an identifying quality, and with seventy-six characters for examination, any one of which may diverge in a number of different ways, this alignment characteristic in typewriting may become highly significant as a means of individualizing the machine. In many instances it alone is sufficient to identify a specimen of typewriting under investigation as having been written on a certain individual machine. This evidence is clearly shown by photographing the typewriting under specially prepared ruled squares on glass.

The third identifying quality is the uniformity or character of impression of each type character. Typewritten letters are impressed by striking against a circular roller, or platen, and the type faces are curved inward to conform to the curvature of the roller. These type, when they print perfectly, strike the roller uniformly and print with an even impression all over the face of the type, but a character may print heavy at either side, or at top or bottom, or may print heavy at one corner and lighter at the diagonal corner. This lack of uniformity is another quality which, with seventy-six characters, affords a means of discovering the individuality of a particular machine.

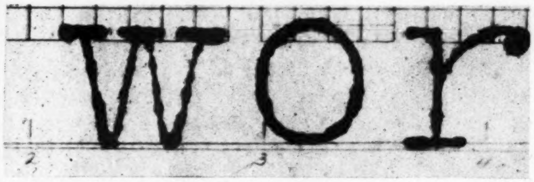
The fourth quality in typewriting by which it is identified is the divergence from vertical position of the straight letters, especially the longer letters. Most typewriting letter designs print vertically, but a letter may lean slightly to the right or slightly to the left, and a careful examination with a special glass protractor will, as a rule, disclose out of seventy-six characters a few characters at least that do not print perfectly in this particular, but which habitually lean a definite number of degrees to the right or left, which affords another means of identification.

Critical Detail.

The fifth quality in typewriting by which it is identified, and in some ways more important than any of the others, is the presence of imperfections in the type faces themselves, or the presence of slight inherent imperfections in the printing type face as made that is shown in the impression of the character. Most typewriting characters are formed by forcing



APPLICATION OF ARCMETER.
1. Modern vertical handwriting. 2. Angular hand. 3. Spencerian.
Arcs are of circles of ¼, 2, and 3¾ inches.



APPLICATION OF A THOUSANDTH-INCH MEASURE BY WHICH ALIGNMENT IS DEFINITELY MEASURED.

soft steel under great pressure into a matrix, or mould, of the letter, and it is intended that the metal shall fill the matrix. Especially where type have sharp edges the printing face may be slightly imperfect as made, or slight but unmistakable imperfections may at once develop when the machine is put into actual use. It is obvious that an imperfection may appear at any point on the face of any character, thus affording thousands of possible identifying imperfections. The delicate extensions of letters are the most likely to be imperfect or may be the first that will be worn away, broken, or battered, by conflicts with the metal part ot the machine or by conflicts with each other. As a machine is used it will inevitably develop many imperfections in the type faces, especially on letters that are frequently used, like the vowels.

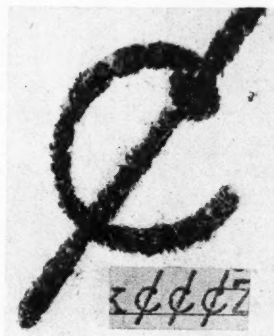


ILLUSTRATION OF CENT SIGN in which a change in slant of the cross marked an important date in the history of a disputed document.

Reasonable Probabilities.

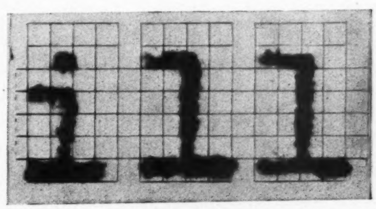
The development of typewriting imperfections in the type faces also furnishes a means of determining the date of a disputed document that may have been written on a known machine. It is readily understood that, if fairly complete and continuous specimens of the work of a machine are available, covering its whole history, that it may then be possible to determine just when the various imperfections developed. In some instances it is possible to determine a date of this kind within a day or two. An extension or portion of a letter may be permanently injured, or carried away, and it will, of course, never print correctly again, and any document containing that defect in that letter must, of course, on that machine have been written after the defect develops. With numerous defects and sufficient specimens of the work of the machine for comparison the date after which a disputed document must have been written can sometimes be determined with absolute certainty.

Taking all these five distinct qualities of typewriting in combination, it will readily appear that a typewriting machine, especially after it has been in use, will produce in its writing a result that is highly individual. It is not an exaggeration to say that with many machines an individuality is developed which makes the machine differ from all other machines manufactured. The possibility of accidental coincidence of numerous of the identifying qualities is so remote that it is entirely reasonable to say that such a combined accidental coincidence is practically impossible. The principle underlying identification by characteristics is, of course, the combination of numerous confirming qualities that all unite in one instance.

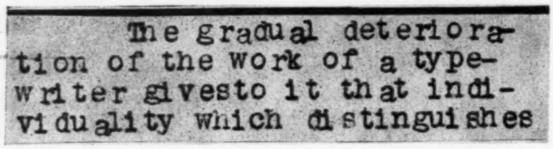
Legal Problems.

Three main questions arise regarding typewriting. First, as to whether a particular document was written on a certain individual machine. Second, whether a document was written all on one machine and written continuously, or whether it was written at two different times on the same machine after the paper had been taken from the machine, or on more than one machine. The third question is whether the date of a typewriting is in harmony with the work of that particular design of typewriter on the date the document bears, or whether the machine on which it was written was actually in existence on the date it bears. It has been shown in numerous cases that a disputed document was written on a machine that was not in existence on its alleged date. It is difficult to imagine proof more conclusive that a document was not genuine.

This last question, and the others referred to above, have arisen in numerous cases, and the American law reports now contain quite an extended list of cases in which the identification of typewriting was the important question in the case. One of the most recent cases of this kind was tried at Saginaw, in the State of Michigan, in October last. The case involved a claim based on a typewritten document which purported to have been written in 1880, and if successful the claim would have amounted to more than a million of

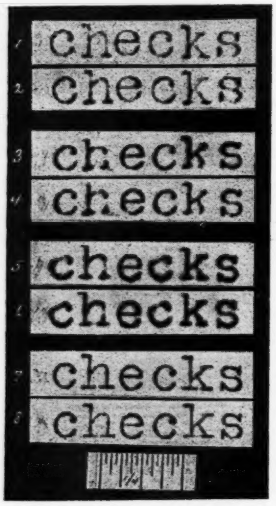


APPLICATION OF FINELY-RULED GLASS INSTRUMENT TO ILLUSTRATE MAL-ALIGNMENT.



SPECIMEN ILLUSTRATING VARIOUS VIOLENT MAL-ALIGNMENTS IN TYPEWRITING.

dollars. The case was carefully prepared, and on the third day of a trial which it was expected would last three or four weeks, a specialist was called as a witness who so conclusively demonstrated that the document could not have been typewritten on its date, and that the signatures were not genuine, that the opposing counsel, on their own volition, went to the presiding judge in the case and admitted that they were convinced that the document was fraudulent and that they would consent to the issuing of a decree to that effect. It was conclusively proved in this case that the document in dispute could not have been typewritten until at least thirty-one years after its date. This same result in actual trials has occurred in at least three different states, and many cases have been withdrawn from court after the facts regarding the typewriting had been discovered and shown.



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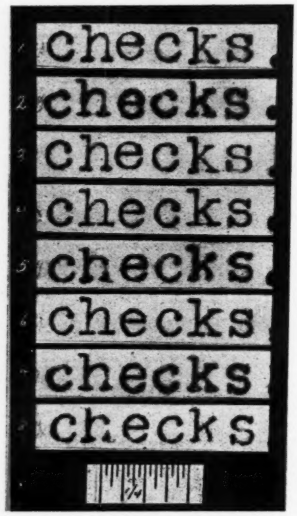


B

A. SPECIMENS FROM FOUR DIFFERENT MACHINES OF THE SAME KIND. 1 and 2. Machines used a short time. 3-6. Two old machines. 7 and 8. One nearly new machine.

B. THE SAME WORDS REARRANGED TO SHOW HOW PAIRS CAN BE SELECTED BY COMPARISON.

Anonymous Letters.

Naturally, the typewriting machine has been used for the writing of many anonymous letters, and the identity of the writer may in this way be concealed, but in a large number of cases it has been possible to show conclusively where the letters came from. In such an inquiry one who has available the reference material on the subject covering all the machines can decide on what kind of a machine the document was written, and then it often is a simple matter to examine the work of a number of possible machines of that kind for the purpose of determining whether or not the document was written on that machine.

This matter of individuality of a particular machine is so incredible to many who have not examined the subject that it can hardly be believed that it is possible to identify in a great city a certain typewriter as the one, and the only one, upon which a particular document was written but, as already pointed out, a careful examination of the question demonstrates that an extended specimen of typewriting may be almost as individual as a particular person as described by measurements, individual marks, and finger-prints.

New Machines.

It is commercially unnecessary to make each typewriting machine write with absolute perfection, and a careful examination discloses certain divergences in entirely new machines which, although microscopic in character, if continuous, furnish a means of identifying the work of each machine. Of course, if two machines, made after the same design, wrote perfectly, their work could not be distinguished, and unfortunately the basis for comparison, or the character of the specimen submitted, sometimes makes it impossible to identify a disputed typewriting, but, as stated above, the identification often amounts to absolute demonstration.

Numerous legal questions have arisen regarding this subject, one of them being the admissibility in court of specimens of typewriting for purposes of comparison, but most of the American courts have now settled affirmatively these various questions. The number of typewriting inquiries is increasing every year, as is natural with the great increase in the number of typewriters in use, and the interests of justice require that specialists should be available in every community who can answer the many important questions regarding disputed typewriting.

A fund amounting to £2,079 has been handed over to Leeds University for the founding of an Arthur Smithells scholarship.

The Moon's Influence on Life in the Sea.

By H. Munro Fox, M.A.

Old doctors who live on the sea coast say that dying folk go out with the ebbing of the tide. Young doctors say they know better. Yet here is some unexplained but accurate science indicating lunar influence on animate things.

THE Royal Society or, as it is more properly called, the Royal Society of London for the Improving of Natural Knowledge, was founded during the reign of Charles II. It consisted of "divers worthy persons inquisitive into natural philosophy." In the early years of the Society the advancement of knowledge was furthered by means of a "correspondency." That is to say, lists of questions were drawn up and sent to "diligent persons" in different parts of the world. These lists of inquiries were recorded in the early volumes of the *Philosophical Transactions* of the Society together with whatever replies that were received. For it was desired to have "confirmations of the truth in these things from several hands before they be relied on."

"Very Inquisitive Men."

Now one of the earliest of these lists of questions was published in 1667, being headed "Inquiries for Suratte and Other Parts of the East Indies." These questions were particularly addressed to Sir Philiberto Vernatti, at that time resident in Batavia. The following question formed one of the series: "Whether those shell-fishes that are in these parts plump and in season at the full moon, and lean and out of season at the new, are found to have contrary constitutions in the East Indies." How this query was answered two and a half centuries after it was asked I shall have to tell below.

The question concerning shell-fishes and the moon which was put by the "very inquisitive men" (to use their own phraseology) who had founded the Royal Society expresses a belief which is most ancient. It is a belief which is found from the days of classical Greece onwards, that the moon exerts an influence on the condition of marine organisms, and more particularly on those sorts which are used for food, such as oysters, crabs, and sea-urchins. Of course, in all countries and at all times there have been innumerable superstitions connected with the moon and her influence on men, women, beasts, plants, and even on inanimate things. To discuss these beliefs would lead one too far afield. I shall restrict myself to those regarding sea creatures. But here alone it is sufficiently striking to see to what extent these beliefs were common property. For they are found as commonplaces in the writings of the poets and orators of ancient Greece and Rome. Aristotle is most precise, telling us that the ovaries of sea-urchins acquire a greater size than usual at the time of full moon. Oppian, in his poem on fishing, the "Halieutica," writes as follows: "The shell-fish which creep in the sea are said, all of them, when the moon waxes to fill up with flesh proportionately to her disc, occupying then a bigger space. On the other hand, when she wanes they shrivel and their members grow thinner." Cicero, too, says that this is true of all shell-fish, and Horace in one of his Satires mentions that "nascent moons fill the succulent shell-fish." Pliny, in his Natural History, refers to the matter in a number of places. He says that "learned men have ascertained that the bodies of whelks, crabs, and echini increase and again decrease under the moon's influence."

We can trace the belief persisting through the Middle Ages, for in the fifth century St. Augustine, in his "De Civitate Dei," writes that "certain kinds of things such as sea-urchins and shell-fish are increased and decreased with the waxing and waning of the moon." And much later—indeed, only a few years before the foundation of the Royal Society—Francis Bacon refers to the same matter. Very characteristically he suggests an experimental inquiry with "oysters and cockles, which are the easiest tried, if you have them in pits."

Popular Beliefs.

Although to-day this belief is unknown to fishermen on our coasts, yet it is quite generally believed all around the Mediterranean. In the fish-markets of Nice, Naples, and Alexandria, sea-urchins are firmly believed to be better eating round about the full moon. So firmly is this theory engrained that in Greece the fishermen throw away all catches taken when the moon is dark. The Tarantines, whose oyster-farms are famous, support the same view, namely, that oysters are fattest at full moon.

Now, although this belief has been so firmly held

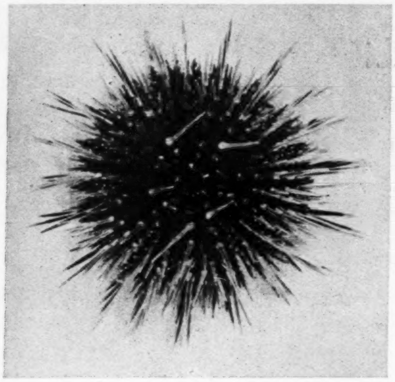


FIG. 1.
SEA-URCHIN.
At Suez these animals spawn when the moon is full.

as we have seen, from classical times until to-day all around the Mediterranean Sea, the remarkable truth about it all is the following. It is altogether untrue that molluscs, sea-urchins, or crabs in the Mediterranean vary with the moon. *But* it is quite true that in another place not so very far off—namely, at Suez in the Red Sea—sea-urchins do obey the moon's phases.

Scientific Facts.

All of this was found out in a thorough scientific investigation of the question carried out during the last three years. At Marseilles, at Naples, and at Alexandria, the condition of oysters, mussels and sea-urchins was examined both macroscopically and microscopically over long periods. In all of these animals differences in bulk depend upon differences in the size of the generative organs which are naturally more developed at the breeding season. Indeed, in the sea-urchin (see Figure 1), which creeps about in shallow water among the sea-weeds, the ovaries or testes occupy the greater part of the internal cavity. It is these organs alone which are eaten. They are much relished by numerous gourmets, being taken raw with a trace of lemon. In the sea-urchin the sexes are separate. Reproduction is carried out by the eggs and sperm being extruded into the sea-water, where fertilization and further development takes place. This process, without union of the sexes, is not quite so wasteful as might at first sight appear. For when several ripe individuals are near together a chemical substance given off by one of them excites the others to shed their genital products. In this way there is more chance of the male and female elements meeting.

The study of the reproductive processes—and consequent bulk—of all of these creatures gave a completely negative result as far as any influence of the moon was concerned. The older authors and the present-day fishermen, then, were completely wrong. This, as stated above, applies to the Mediterranean, but on the other hand a most positive lunar influence was found on the reproductive processes of sea-urchins in the Red Sea.

But before going into the details of this, I must deal briefly with yet another false belief. At Suez it is very firmly believed by the natives that the amount of flesh to be found in crabs varies with the moon's phases. Here, of course, is a different matter from the case of the molluscs and sea-urchins. For in the crab it would be the muscles (the " flesh "), not the ovaries and testes, which would vary periodically. The crab caught for eating at Suez (*Neptunus pelagicus*), is shown in Figure 2. It is a fine blue-and-pink kind with the hind legs flattened as swimming paddles. Now a search for a lunar rhythm in the flesh-content of this crab gave the same negative result as with the Mediterranean shell-fish. Here again the natives are wrong.

It was not the crab but the sea-urchins at Suez which bore out the natives' testimony. The Red Sea urchin (*Diadema setosum*) is a most magnificent creature. Its body is only as big as a lady's fist, but the spines are very long, so that the diameter of a large individual, from tip to tip of the spines, reaches well over a foot. The colour is of the darkest purple with five turquoise blue so-called eye-spots. The ends of the spines are very sharp and easily enter the skin where they break off. A stinging poison enters the wound and smarts badly. In carrying out the investigation, therefore, thick gloves had to be used.

Rhythmic Cycle.

The facts, as they turned out, were these. During the week preceding the full moon the five ovaries or testes, according to the sex of the individual, are large and swollen. Examined microscopically they are found to be packed full of ripe eggs or spermatozoa ready to be shed into the sea. The spawning actually takes place during the few days before and after the full moon. While the moon is waning an examination of the generative organs shows these to be shrunk. They are now empty. Towards the time of new moon, however, new cells multiply and begin to fill the shrunken organs. As time goes on these cells turn into a fresh crop either of eggs or of sperm. These cause the ovaries or testes to swell out anew and they ripen in preparation for spawning at the next full moon. This rhythmic cycle takes place six times each year from April to September. During

the winter months no breeding at all occurs, and so there is no lunar rhythm.

Now it is clear that such a regular and marked change in bulk of that part of the urchin which is eaten could not escape the notice of those who appreciate these succulent morsels. It is only astonishing that in Greece, too, they believe that this occurs, and believe it so firmly that they throw away good catches, whereas it does not happen there at all. I was unable to study the question farther south than Suez, and so do not know whether it may perhaps be a general tropical phenomena. It is believed at the Marquesas Islands in the Pacific (where the urchin has blunt spines six inches long used by the native children as slate pencils). But we have learnt to mistrust beliefs.

Origin of the Myth.

The existence of the lunar reproductive periodicity in the sea-urchins at Suez gives a clue to the reason for the belief in the Mediterranean—a belief which although founded on error goes back to classical Greece. It is possible that in Pharaonic times in Egypt the facts about the Suez urchin became known, and that in the popular mind they became extended to all "shell-fish." Later this would come to be believed not only of the shell-fish caught at Suez (*e.g.*, the crabs discussed above), but also of the urchins, oysters, etc., found on the Mediterranean coast of the Delta. Now it is, of course, well known that not only did many influences of Egyptian culture pass over to Greece, but Egyptian superstitions followed the same path. Thus the false generalization about the moon's influence would have found its way into Aristotle's writings, into those of less distinguished authors, and finally into the public mind in Greece and other Mediterranean countries. There it has remained implanted until to-day, handed down by verbal tradition.

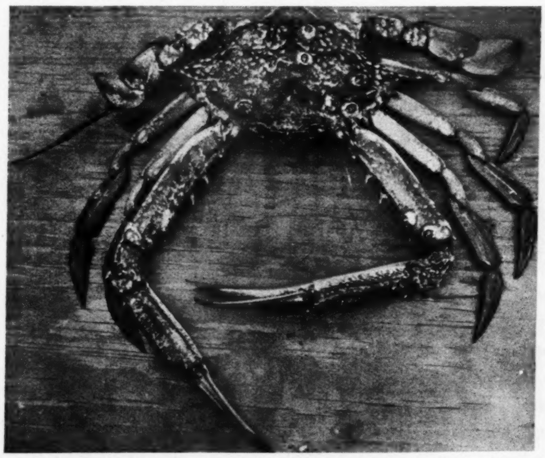


Fig. 2.
SWIMMING CRAB FROM SUEZ.
The natives believe that the amount of flesh in these shell-fish varies with the moon's phases.

Be this as it may, there is another aspect of the question of lunar periodicity which is of much greater importance to the biologist: that is the question of the causes of this periodicity. In what manner does the moon influence the sea-urchins?

Now the most obvious rhythmic effects of the moon on the earth's surface are the tides and moonlight. It is natural, therefore, to look first to one of these as the cause of periodicity in the sea-urchin *Diadema*. It is already known that the tides exert an influence on a number of shore-living organisms, impressing upon them a rhythmic behaviour. I am not thinking for the moment of a twelve-hour rhythm due to the ebb and flow which occurs twice daily. That too exists. Certain sea-anemones, for example, are forced to retract their tentacles twice a day when left high and dry by the receding tide. These anemones when kept in an aquarium still draw in their tentacles twice daily, although now removed from the tidal influence.

However, it is not this but a fortnightly rhythm due to the spring and neap tides which bears more closely on our problem. Every fourteen days, when the sun and moon are in conjunction or in opposition, the tidal water rises higher and falls lower than the ordinary. Once a fortnight then, at the lowest tides, the shore creatures are more exposed to the air, heat, and light. This would affect their respiration and impress upon them a fortnightly rhythm in many of their vital functions. For example, certain marine worms lay their eggs only at each spring tide; certain sea-weeds produce a crop of sexual cells at fortnightly intervals.

Tidal Theory.

The absence of a lunar rhythm in the reproduction of the Mediterranean urchins and its presence at Suez would argue a tidal cause here too, for the tides are well known to be almost non-existent in the Mediterranean, while they are considerable in the Red Sea. Yet at home, where the tides are bigger still, there is no lunar rhythm in the urchins. And further reflection shows that the tides cannot really be the cause of the Suez sea-urchin's periodicity, for the urchins spawn not at each spring tide but at every second spring tide—that is to say, at full moon—once a month, not once a fortnight.

After tides the next most obvious possible lunar cause is the light of the moon. But the additional

light falling on the animals at full moon is an insignificant proportion of that received by them daily from the summer sun in an Egyptian cloudless sky. Full moonlight is only one six-hundred-thousandth of the intensity of sunlight. Nevertheless, this does not conclusively put the moonlight out of court. The matter, though, might be decided by experiment. Urchins kept in cages would be exposed for long continuous periods to artificial light and to darkness. The experiment would be costly, for several hundred individuals, each a foot in diameter, would have to be caged.

Unsolved.

Before leaving the possibility of a direct influence of the moonlight, it should be remarked that in the Red Sea the summer nights are cloudless, so that the urchins get the full benefit of the moon's radiation. In northern climes this is very different. Furthermore, at Suez the creatures live close in to the shore in shallow water (Figure 3), which again exposes them directly to the moonlight.

Fig. 3.
SITUATION AT SUEZ WHERE THE SEA-URCHINS ARE FOUND WHICH BREED AT EACH FULL MOON.
The laboratory in which the research was done is shown.

The material to build up the bulky new ovaries each lunar period must necessarily come from without. Yet no difference could be detected in the gut contents at any period of the moon which would denote more active feeding.

In conclusion one further case of the moon's influence on the breeding of a marine animal must be mentioned. It is a case which has been known for many years. I refer to the Palolo worm living in Pacific coral reefs. This creature does not spawn at each successive moon like the Suez urchin. It spawns once a year only, and this always occurs exactly at the last quarter of the October moon.

The worm lives in crevices in the coral rock. The eggs or sperm are formed in the hinder half of the creature. Just before spawning this back half breaks off from the head end and wriggles up to the surface of the sea. Countless millions of the worms behave in this way at the same time, so that the surface waters resemble a greenish soup. The natives know beforehand by the moon's phase when this swarming of the worms is about to take place. They come out in boats and simply scoop up the worms in nets and buckets. Subsequently the worms are cooked and eaten.

Still, the immediate causes of these remarkable lunar periodicities remain undiscovered. But a number of obvious possibilities have been ruled out, in the case of the Suez urchin at least. And in a scientific inquiry as soon as a problem is properly expressed it is half solved. Doubtless further light will be shed on this particular problem when other cases have been studied. Most probably marine laboratories in tropical seas will be the places where such cases will be found. Unfortunately, at present such laboratories are almost non-existent. The Suez investigation was carried out in a makeshift laboratory installed in a quarantine station (see Figure 3).

PEAT.

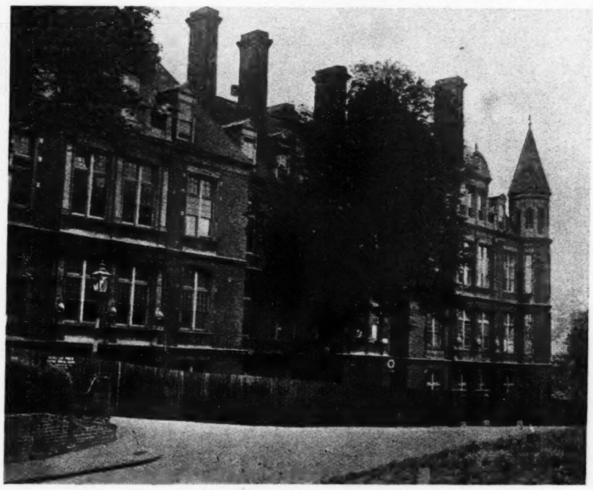
A PEAT fire is a familiar sight in many Scottish and Irish households, and has been so from time immemorial. Although suitable as a domestic fuel there are several drawbacks that make it impossible to use it for industrial uses, such as heating boilers or furnaces. The greatest of these is the large amount of moisture that is absorbed in it so thoroughly that pressing will not drive it out. A Canadian firm announces that it has now devised a practical method for eliminating this water, and it is now commencing to develop the enormous peat bog at Alfred, Ontario. It is estimated that there are between two and three tons of peat in the bog, and that this will now be available to manufacturers in the area between Montreal and Winnipeg; an area that is devoid of coal. It will thus take the place of fuel that to-day has to be transported many hundreds of miles. The development should therefore be truly economic.

Great Britain's Medical Research Institute.

By Charlotte Burghes.

When the news was published in the English Press that two British research workers, Dr. W. E. Gye and Mr. J. E. Barnard, had at last discovered the filter-passing organism which produces cancer, it was immediately realized to be of international importance. But apart from a few experts in pathology and microscopy, the public heard for the first time these two names. The information that the research had been conducted for nearly four years at the National Institute for Medical Research at Hampstead, a hill-top suburb of London, focussed British attention on this Institute, which is a Government Department, financed out of public funds subscribed by the taxpayer. What the Institute is, and what is at present being achieved there by picked research workers, is described in the following article.

THERE are few British research workers who, from time to time, do not look enviously across the Atlantic to the land where public imagination has been thoroughly aroused to the marvellous vision of science and where, in consequence, all those engaged in its elucidation can realize their desires for the ideal setting for their work. It is told with awe in the laboratories how the Rockefeller Institute has unlimited millions at its disposal.



WHERE CANCER IS BEING FOUGHT AND WILL BE CONQUERED.

Funds.

The professor who must endeavour laboriously to find a paltry hundred pounds a year to supply the minimum wants of a particularly brilliant research student, longs wistfully but vainly for such perfect conditions in Great Britain.

Amid the horrors of the recent war there were one or two benefactions whose value to Great Britain did not appear clearly until its closing years. The chief, perhaps, of these, was the enlightenment which came at last to politicians and public with regard to the value of medical research. A Medical Research Committee had been set up in 1914 to give some encouragement to scientific investigation but its aspirations, like many others, were speedily swamped in that historic year. By 1920 the position had substantially altered. It was generally realized that such work could no longer depend on the dubious bounty of private individuals. The Medical Research Council was therefore incorporated under the direction of a Ministerial Committee of the Privy Council.

A grant of approximately £140,000 was provided by Parliament for the Council's needs last year and, paltry as this sum may appear by comparison with the annual income of the Rockefeller Institute, it has been sufficient to secure an environment in which magnificent advances, culminating in the cancer discoveries, could be made. The results are probably mainly due to the fact that the organization provides for conditions under which those mainly responsible for the distribution of the money are the most eminent research workers in the biological sciences in the country.

Two-thirds of the Council's income is devoted to grants to students at the universities and the hospital schools. The remaining amount goes to provide a centre in which a few workers of outstanding ability may give themselves, without distraction or financial embarrassment, to the study of a chosen field in physiology and bio-chemistry, pathology and bacteriology, applied optics, and statistics.

A Quiet Site.

Under these conditions immediate results are not looked for and, in consequence, these workers can afford to ignore the mundane anxieties which are so detrimental to the success of pure research.

Immediately after the war the Council proceeded to convert an ex-hospital at Mount Vernon, one of the highest hills in the delightful London suburb of

Hampstead, to this purpose. The building afforded excellent facilities for conversion. The spot could well have remained untouched by the modern transformation of the huge city; it is reached by winding lanes on which the walled gardens of Georgian houses abut; the country breezes which sweep over it bear the song of the lark and the nightingale in the springtime, but the purr and rattle of street traffic does not penetrate so far. From the roof of the Institute the view embraces the smoking city to the Thames's edge and the farther Surrey bank; the height affords admirable conditions for experimental work on atmosphere and temperature.

Equipment and Facilities.

In spite of its advantages, however, there are few signs of luxury about the interior of the Institute itself. The ingenuity of the administrative staff has been challenged to the invention of "gadgets" which could adapt existing material to purposes and needs as they arose. To quote one small but significant example, it may be mentioned that the storage of large quantities of oats was necessary for the feeding of a portion of the 3,000 animal inmates which are housed there. An outhouse was converted to the use and, by the simple expedient of lining it with a quantity of slate tiles which were available on the premises, it was found possible to protect the oats from decay or sprouting.

Such ingenuity can best be displayed in circumstances where funds are not at hand for a lavish expenditure on accessories. The work and organization of such an institute cannot be adequately pictured without reference to such a detail, as well as the up-to-date engineering and carpentering workshops on the premises, whence anything can be produced, from an elaborate wind-tunnel for the experiments of the physiologists, to the wooden hutches wherein dwell rabbits, rats and mice by the thousand. From these pure races are bred according to the requirements of those who play towards them a part similar to that taken by natural selection in the case of their wild relations.

Apart from pure research, the Institute performs two duties towards the public both of which are of immense value. The first of these consists in the study and collation of statistics of vital interest in the matter of public health. During the course of researches at the famous Record Office in Chancery Lane, London, there were found a series of volumes relating to the ages and diseases of the population of the British Isles from the year 1850 onwards. It had been proposed to destroy these apparently useless papers, which in the eyes of no one but a medical statistician could be considered of value. Fortunately, they were retrieved in time, and are now safely housed at Hampstead. The scientific study of epidemiology is at last fully appreciated. A sidelight on the importance of such team work as is possible at Hampstead is thrown by the fact that, while in the laboratories upstairs Dr. Gye and Mr. Barnard were seeking to isolate and photograph the cancer organism, in a room on the floor below Dr. Brownlee, the statistical expert, was engaged, among other studies, in collating statistics referring to the occupational incidence of cancer, the association of which with certain callings appears in an entirely new light since the publication of Dr. Gye's paper revealing the connection of the organism with a specific factor which encourages the development of the disease.

Dr. Brownlee has a pretty taste in apparatus by means of which he is enabled to reduce a welter of figures to instructive order. His reports are prepared by means of an electrically-driven calculating machine, while a charting machine, capable of ruling plain paper to within one hundredth of a centimetre, is used for the construction of faultless diagrams.

The second outstanding service rendered to the public consists in the testing of new "cures" for diseases such as tuberculosis, and the standardization of the products of the commercial laboratories. It was under the direction of Captain Douglas, of the department of Experimental Pathology, that the tests were carried out in England of Dr. Dreyer's "diaplyte" vaccine. The high hopes at first entertained that this might at last be the means of curing tuberculosis have unfortunately not been substantiated, but without the co-operation of the Medical Research Council, and the mobilization of its resources, it would hardly have been possible to put this substance to stringent investigation within so short a time.

Testing Services.

The fact that the products of British manufacturing chemists can be bought and used with full confidence by the public, is accounted for when it is learnt that the makers welcome the testing of their preparations by the Medical Research Council, which has mobilized a large department of its experts for the purpose. Thus, on the announcement of the discovery of insulin by Dr. Banting, it was at once realized that steps must be taken to prevent the public being victimized by quacks, who might seek to put alleged insulin of no value on the market. An arrangement was accordingly made with the University of Toronto, which had

wisely taken out a patent for insulin to prevent the same kind of abuses, whereby its representation in Great Britain was vested in the proper authorities. Work in the production of insulin was immediately undertaken at Hampstead, as well as in laboratories such as the Biochemical Laboratory at Cambridge, which includes among its students those receiving grants from the Council. In this way purity in production, and lowering of the price to the public were quickly assured, and as soon as standardization was achieved the preparation of the substance was turned over to the commercial manufacturers, who performed it under licence from the Medical Research Council, repeatedly forwarding samples to the Institute in order that they might be tested there. A similar procedure is followed in the case of most drugs and new medical preparations, and it is not difficult to realize the enormous value of this work to the British public.

It is not surprising, perhaps, that in the domain of pure research it should have been Mr. J. E. Barnard who has focussed public attention on the Institute at Hampstead. Dr. Gye, whose experiments have been conducted mostly on fowls, found it more convenient to work at the Institute's experimental farm at Mill Hill, an outer suburb. The farm comprises 38 acres of land, and thus offered facilities which could hardly be found in the limited gardens at Hampstead, already partly overbuilt with outhouses. The unique position and personality of Mr. Barnard can best be appreciated by trained scientists and research workers themselves.

Mr. Barnard's Work.

They alone know the rarity of the appearance among them of the amateur whose gifts are sufficiently great to enable him to work by their side, not merely as a tolerated assistant and enthusiast, but competent to hold his own with the very greatest masters. One or two such men have appeared in the past, and have made scientific history. It has been usual, in such cases, to speak of genius. Whether or not it is appropriate to apply such a term to one still actively engaged in the pursuit he has chosen may be debatable, but it is difficult to avoid the thought of it in this particular case.

Mr. Barnard may justly be described as a business man in whom a rare gift has happily not been stifled. Microscopy is a science which, above all others perhaps, must appeal to the aesthetic sense. Craftsmanship, invention, and perfection of the instrument in the degree to which it has been carried here, must evoke the same quality of admiration as the colours mixed by a Rubens, or the violin evoked by a Stradivarius.

Mr. Barnard devotes his mornings to business, and spends the rest of his day with his assistants, Mr. J. Smiles and Mr. F. V. Welch, in three large rooms on the first floor of the Institute. The first is fitted up for X-ray work, the second is an ample laboratory containing a corner for the tubes wherein the colonies of filter-passers await their turn before the microscope-camera. Mr. Barnard's contribution to the cancer discovery lay in his ability, thanks to his outstanding mastery of optical methods, to devise the special apparatus which would overcome the hitherto known limits of microscopical observation, and so make photography by transmitted light of very short wave-lengths possible. The chief requirements of the microscope itself were a degree of stability and accuracy which had hitherto never been obtainable, even in the very best available.

A Marvellous Microscope.

In the third room, where the mercury vapour lamp and this microscope are installed, even the simplest individual would feel a vicarious pleasure in contemplating their exquisite precision and delicacy of adjustment, and in remembering that it was here definite evidence as to the constitution of the filter-passing group of human and animal scourges was first obtained.

The point to bear in mind when trying to follow Mr. Barnard's methods and results is that the discovery of these minute organisms was not brought about by more powerful magnification, but by an amazingly ingenious technique whereby it became possible to use wave-lengths of light far shorter than any hitherto employed. The apparatus was so designed that it could be used both for ultra-violet photography and the dark-ground method, which consisted chiefly in eliminating every shred of direct illumination, so that the infinitesimal object appeared as self-luminous by the light it deflected or scattered itself. If one may once again use the well-known analogy with criminological methods, one may say that the invisible criminals were forced to reveal themselves. In the dark-ground work the slides on which they lie as a thin film were not stained as in the usual microscopical technique, but the evil-doers were alive, and busily occupied with their curious reproductive behaviour. The sensations of the onlooker privileged to see the photographic records made by themselves with the assistance of the ever-probing scientist are equally influenced by the emotions of pride and wonder.

Reviewing the organization and the results obtained at the National Institute, one must admit that there

(*Continued on page 452.*)

Helmholtz's Physiological Optics.

(Translated from the Third German Edition).

The Optical Society of America have undertaken the task of publishing Helmholtz's great work in an English translation. Two volumes have appeared, the first of which is reviewed in this article; a third will appear shortly.*

THE Optical Society of America is to be congratulated sincerely on its energy and enterprise in publishing a translation of this famous work of Helmholtz as a commemoration of the hundredth anniversary of his birth.

The first German edition appeared in the year 1866, and the third and last posthumous edition brought up to date and greatly enlarged by Gullstrand, von Kries and Nagel, was published in 1909.

Although Prof. Southall is responsible for the translation he has had the assistance of numerous collaborators whose names are mentioned in his preface.

The first forty pages of the book contains a short description of the anatomy of the eye. As it was written so long ago as 1866 it is not surprising that it is in some respects inaccurate, according to present knowledge; these inaccuracies are, however, pointed out in initialled footnotes.

In dealing with the measurement of the dimensions of the eye such as the radii of curvature of the various surfaces and the axial thickness of the parts, Helmholtz describes the well-known instrument called the Ophthalmometer which he devised expressly for this purpose. In using the instrument a small object is observed by the aid of a telescope through a pair of abutting parallel plates of glass set in one plane, but capable of being rotated in opposite directions. When the plates are rotated double images are seen and the separation of the images and, consequently, the size of the object, can be calculated from the thickness and index of refraction of the glass plates and the angles through which they are turned. The radius of curvature of the cornea can be determined by measuring the size of the corneal reflex of a small object of known size. The apparent distance between the two images is independent of the distance of the object and small movements of the observed eye do not affect the result.

A correct knowledge of the form and position of the iris is very important in the theory of accommodation. Helmholtz describes the experiments which show clearly that the pupillary edge of the iris is applied closely to the anterior surface of the crystalline lens, and also shows how the position of the centre of the pupil may be determined by the ophthalmometer.

The conception of the centre of rotation of the eye was not formed at the time of Helmholtz, and he obviously considered the centre of the exit pupil to be the point of intersection of the chief rays of imaging pencils. It is of great importance in the design of spectacle lenses to know the exact distance of the centre of rotation from the vertex of the cornea and it may be hoped that the wider knowledge of the ophthalmometer and its method of use, diffused by this book, will lead to a modification of the instrument which will enable it to be used for measuring this distance.

Section eight gives the three sub-divisions of the subject:—

(1) The theory of the path of the light in the eye or the dioptrics of the eye.

(2) The theory of the sensations of the nervous mechanism of vision.

(3) The theory of the interpretation of the visual sensations.

Subdivision (1) is dealt with in the remainder of the volume; (2) and (3) will doubtless be contained in the remaining two volumes, one of which is in the hands of the printer and the other is promised within a year.

The Dioptrics of the Eye.

This part of the book, sections nine to sixteen, occupies about 200 pages. Section nine deals with the laws of refraction and their application to refraction by a single spherical surface and by a centered system of spherical surfaces. All the usual first order equations are deduced, the six cardinal points are defined and the usual diagrams for tracing paraxial rays through a system and for finding the position and size of an image are given. The positions of the cardinal points of a compound optical system composed of two systems with their axes in the same straight line are found.

All this is, of course, very familiar to us now, but those of us who are old enough can well understand what a boon it would have been to students of optics if this translation had appeared, say, even forty years ago, when nothing of the kind was available for English readers.

*The volumes can be obtained at $7 each from the Secretary of the Optical Society, Cornell University, Ithaca, N.Y., U.S.A.

In this section is enunciated and proved the famous law of geometrical optics expressed by the equation

$$n_1, \beta_1 \tan \lambda_1 = n_2 \beta_2 \tan \lambda_2$$

where n_1 and n_2 are indices of refraction, β_1 and β_2 the sizes of object and image and λ_1 and λ_2 the angles which a ray coming from, or to an axial point, make with the axis before and after refraction; in other words, the expression is one connecting the linear and angular magnification without involving directly the distance of the object or the focal lengths of the refracting surface. Helmholtz, although he discovered the law independently, found that Lagrange had published a special case of the general law in 1803, but he appears to have overlooked the fact that Robert Smith in his Compleat System of Optics (Vol. I, p. 111, Cambridge, 1738) had long before enunciated and proved this law for a system of thin lenses.

Its Optical System.

Section ten applies these general principles to the optical system of the eye which is compared to a camera obscura. The field of view, however, is very large, being approximately a hemisphere; in near vision the pupil is displaced a little towards the cornea thereby somewhat increasing the field.

The *main* refraction of the system is at the cornea; next in importance are the refractions at the two surfaces of the crystalline lens. The positions of the principal, nodal, and focal points are subject to considerable individual variations. When the eye is adjusted for distant vision the two principal points are very close together as are also the two nodal points.

The data assumed by Listing and the positions of the six cardinal points calculated from them are given and Helmholtz says (p. 95) "There is no reason to doubt, therefore, that Listing's model agrees about as well with the actual facts as can be expected with the wide variation that exists in individual eyes." In Listing's "reduced eye" the two principal points and the two nodal points are supposed to coindice, and Helmholtz gives a very useful tip when he tells us that "the optical behaviour of this reduced eye is equivalent to that of a single spherical refracting surface whose centre and vertex are at the nodal point and principal point, respectively, the first medium being air and the second medium the aqueous or vitreous humour. The radius of curvature of such a surface would be 5.1248 mm."

The direction of the visual axis of the system of the eye is a line drawn from the point of fixation to the first nodal point or from the second nodal point to the centre of the fovea and the optical axis is a line passing through both principal and nodal points. Helmholtz's investigations showed that these two lines are quite distinct from each other, the part of the visual axis lying in front of the eye being on the nasal side and usually a little above the optical axis.

The optical system is made up of the two partial systems: (1) the cornea; (2) the crystalline lens. As regards (1) Helmholtz first shows that (p. 99) "for calculations of images, therefore, it is accurate enough to assume that refraction occurs simply at the anterior surface of the cornea and to put the index of refraction of the cornea equal to that of the aqueous humour." As regards (2) the crystalline lens may be considered as immersed in the same medium so that its principal and nodal points coincide. The density of the crystalline lens increases from the outside towards the centre. Helmholtz did not know the law of increase but he finds that the focal length of the crystalline lens and the interval between its principal points are less than they would be if the index of refraction were uniform.

The section concludes with an account of the methods and apparatus used for measuring the indices of refraction of the various media and the positions of the nodal points and of the visual and optical axes.

Section eleven is concerned with blur circles on the retina produced when the eye is so focussed that the object point is not conjugate with the retina. This leads up to a consideration of accommodation in general. Scheiner's experiment of looking through two pin holes a distance apart less than the diameter of the pupil is discussed. Although the terms entrance and exit pupil were not used by Helmholtz, the idea underlying them was well known to him. Formulae for calculating the size of the blur circles are given, but I do not find anything about the size of the blur circles on the retina produced by a pencil which fills the pupil when the object point *is* conjugate with the retina. This depends on the spherical aberration of the eye and is of some importance as a distinguished English writer uses the idea as the basis of his method of designing spectacle lenses free from astigmatism.

Accommodation.

The next section deals very fully and clearly with the facts and theories of accommodation. The main facts are: (1) The pupil contracts in accommodation for near vision and dilates for far vision; (2) The pupillary margin of the iris and the centre of the anterior surface of the lens move forward slightly in incipient accommodation for near vision; (3) The anterior and posterior surfaces of the lens become more convex in near vision and less convex for far vision.

Many antagonistic opinions and theories have been entertained concerning the action and mechanism of accommodation. Helmholtz discusses them under the headings :--

(1) Theories that deny not only the necessity but also the existence of any change of the optical system of the eye ;
(2) Opinions which consider the contraction of the pupil as sufficient to account for accommodation in near vision ;
(3) Opinions that involve a change of curvature of the cornea ;
(4) The supposition that accommodation is produced by a shifting of the position of the lens ;
(5) Hypothesis of change of form of the lens ;
(6) The supposition that the form of the eyeball changes.

The author concludes that he sees no reason to modify his own theory as given on p. 151, the main points of which are " In the passive far-seeing state of the eye the lens is stretched by the zonule attached to its edge. On contraction, the ciliary muscle could pull the posterior end of the zonule forward nearer the lens and reduce the tension of the zonule. But the effect of the tense zonule is to exert a pull on the lens along its equatorial diameter, and thus to shorten its axis and make its surface flatter. If the pull of the zonule is relaxed in accommodating for near vision, the equatorial diameter of the lens will diminish, and the lens will get thicker in the middle, both surfaces becoming more curved. If the pressure of the iris is super-added, the equatorial plane of the lens will bulge forward, increasing the curvature of the anterior surface and decreasing that of the posterior surface, so that the latter may be approximately equal to its original amount when the lens is accommodated for far vision."

The next two sections treat of the aberration of the eye due first to the different refrangibility of different wave-lengths of light, and second to the surfaces not being spherical. These are called chromatic and mono-chromatic aberrations, the latter of course, including spherical aberration and astigmatism.

Entoptical phenomena form the subject matter of the next section. Under suitable conditions of illumination it is possible to render visible certain objects or their shadows within the eye itself. These include irregularities in the form of the pupil, ridges, specks, etc., on the various surfaces and moving particles in the humours.

The last section is of first-class importance, and is really a condensed treatise on the theory of the ophthalmoscope and the illumination of the fundus. Helmholtz's invention of the ophthalmoscope was an immortal service to mankind ; he built better than he knew, for the photography of the fundus and all that this means was rendered possible by his instrument and by the principles of illumination which he laid down.

The book concludes with six appendices, by A. Gullstrand, which occupy some two hundred pages.

The translation has been excellently done ; the type is large and clear ; the proof-readers have been very careful ; the book is beautifully turned out and is a worthy and appropriate monument to the memory of a great man.

LINALUDO: THE KNIGHT'S TOURS.

By ARCHIBALD SHARP, B.Sc., A.M.I.C.E., F.C.I.P.A. (E. Marlborough & Co., Ltd.). Instruction Book, Two Sketch Books, 4/- per set.

As an interesting pastime which has the advantage of exercising ingenuity, the game of Linaludo should afford ample scope for intellectual recreation. It is a form of "Patience" without cards : paper and pencil only are required. The foundation of the game is based on the well-known knight s move in chess ; and although some skill is required in arriving at the solution, a knowledge of chess is not necessary for the purpose. The illustrated book of instructions contains many examples, and with it are included two sketch books, which complete the set.

BENZOATES IN FOOD.

READERS will need no reminder that in the proposed changes in the law affecting the use of preservatives in foods boric acid will be forbidden and replaced in many instances by benzoic acid and its salts, the benzoates. During the recent very heated controversy in *The Times* and elsewhere there were many writers who stressed that the physiological effects of benzoic acid were too little known. This is only too well revealed by some recent work on the elimination of benzoic acid and benzoates from the body. It was found that after administration of several doses of sodium benzoate it took three days before the benzoic acid was completely expelled. The investigators therefore give it as their opinion that this difficulty of elimination makes benzoic acid and its salts a dangerous substance to use as a preservative of foodstuffs.

The Condition of the Scientific Worker in Soviet Russia.

By Ivor Montagu.

The value of the intellectual worker has been assessed by the new Russia. The author has spent several months working in Russia and gives us a scientist's view of the facts.

THE role of the scientific worker, in any society, is that of poor relation to the governing class. Scientific work, by its nature, demands material convenience, in the sense of absence of distracting physical discomfort—and independence, in the sense of ability to regulate and determine its course whithersoever bound, without reference to external authority. But leisure and freedom to this degree are privileges restricted to a governing class; and the scientist is always prevented, by the engrossing character of his research, from winning the economic power which would secure him a place in that class. Thus that society which includes the scientific worker as an integral part, while conceding to him a measure of the facilities without which his work could not be carried on, does so with the haphazard manner of one distributing alms, rather than as an acknowledgment of due right. In what is called a capitalist society, in England for example, the relations between the laboratory or research group on the one hand, and the governmental body that feeds it on the other, have that air of deference met by fortuitous patronage which characterized the attitude of the local dominie to his village squire in more moss-grown centuries. And in Russia of to-day, where the privileged class is proletarian, the scientist ranks as least honoured of Workers, most tolerated of Bourgeoisie.

Class War Results.

To make this plain we must first examine the new caste system and social snobberies of urban Russia. There are two main castes, corresponding roughly to the ideology of the class war. On the one hand we have the Workers (wide sense), a term embracing labourers, skilled labourers, office workers, artists and pure scientists. These people all exist on meagre salaries eked out with privilege. On the other are the Bourgeois, who are the private employer or N.E.P. man, sanctioned by the new economic policy, and the applied scientist, often an engineer or manager, who owes his existence to Lenin's phrase "Use the experts." The earnings of the N.E.P. man are technically unlimited (of course, actually there is a government tax graduated less by an objective law than by his capacity to stand bleeding), and the wages of the expert are disproportionately high. The labourer works, urged by a religious pride and enthusiasm in his belief that he owns the country; the artist and the pure scientist work, as they always do, because they like to and can't help it; but the expert, who feels as "out of it" as the workman in England, ca's canny and has to be tempted by high wages.

Workers' Privileges.

On wage, we have grouped the pure scientist with the worker caste. A university assistant's minimum wage in Moscow is perhaps fifty roubles a month (£5), compared with the thirty-five roubles of an unskilled labourer; professors, perhaps round about a hundred roubles, like an engine-driver, though in rare cases more. In physical privilege, the pure scientist shares also, and in some respects exceeds, the conveniences of other members of the worker caste. For the Bourgeois, prices are raised and all circumstances made difficult. For the Worker, his wages are augmented by reduced prices in co-operative shops, by cheap tickets in the theatres, statutory holidays on full pay, houses at a far less than economic rent, and the like. Rest houses, sanatoria, and excellent clubs are available for him. To a certain extent he controls his conditions of work through committees functioning independent of his factory management. The pure scientist also has his rest homes and sanatoria, even if, as is possibly the case, it is harder for him to get into them than it is for a labourer to enter the working ones. He has entire control over his conditions of work. He is provided with an organization called Tsekubu, or the Committee of Relief for Scientists, said to have been established by Lenin, at the request of Gorki and Oldenburg, to preserve a few during the starvation period. At present it functions by maintaining hostels in Leningrad and Moscow, the latter equipped with excellent bedrooms, dining gardens, reading rooms, and tennis courts, where the visiting scientist, attending some conference or otherwise transplanted, can live for a nominal fee (compare one or two roubles a night with eight to fifteen in the crowded Moscow hotels).

The differences to his privilege relate to the fact that he, in common with office workers and certain skilled grades, is labelled "Intellectual Worker." The Intellectuals have larger holidays and shorter

hours. In Moscow, where houses are rationed, they have special dispensation. In Moscow the population is so much greater than before the war, partly because it is now the capital, that the housing problem is acute. Each Worker's family of man, wife, one child, is limited to a statutory amount of space, in practice usually one room. But each Intellectual is entitled,

Political Shackles.

still at nominal non-economic rent, to two rooms at least, for it is recognized he cannot always work to hours, and must be able to write at home yet relatively free from the domestic distractions of his wife. But there are considerable disadvantages in the title Intellectual. A minor one, which perhaps little disturbs the pure scientist, is that it is hard for him to enter the Communist Party, and he is thus practically debarred from any part in political or civil administrative life. The Communists are jealous to preserve the pure-milk proletarian character of their party. A labourer must be proposed by two members, each of three years' standing in the party, and patient himself during a year's probation. But an Intellectual must be proposed by three members, each of five years' standing, and survive two years' waiting as a candidate.

Sir Martin Conway has described the flourishing health of the art collections of Russia. The scientific museums and laboratories are in an equally happy state. They are administered by scientists with a minimum degree of interference (in Tsekubu's reading rooms are several foreign publications banned or difficult to obtain in the ordinary shops, and the Academy of Sciences has the right to export scientific publications without submitting them to the censor), and the government provides them with increasing sums of money. In my own line, systematic zoology, for example, there is probably as much or more money for research than in England. I was hardly concerned with a single zoologist, of appropriate age and sufficient stamina, who did not find it possible to go on expedition at least once a year. A vast amount of work is being done. Publication is not so happy. Though it is easy to do research in Russia, it is hard to get it published. Last year, for example, the Zoological Museum of the Academy of Sciences published nothing at all. When I raised this point to the authorities, I was answered that all paper is imported, and its amount limited by credit difficulties. A great deal of paper is needed for education, newspapers, propaganda, novels, and the like, but the situation is none the less regrettable. However, the younger scientists are nothing deterred, they are all learning English and striving to publish their work here or in America.

In fact, all the pure scientists are working well and enthusiastically. I have met only one who neglected his research, complaining that his pay was so small he must enlarge it by writing children's books and natural history stories, and that this left him no time for the Museum. Most, of course, eke out their monthly wage by some such means, but they work double time for the purpose, and their proper task does not suffer.

So much for the physical circumstances. To complete the picture, word must be added of the scientist's social status. The Russian proletarian, rightly or wrongly, is passionately persuaded that the country is his, that Russia is a "People's Republic." He is now powerfully indoctrinated with the simple ABC of socialist ethics, that it is wicked to exist on another man's labour, that it is a splendid thing to be a workman, and a sad shameful wickedness to spend more money than other people, and so forth. Hence he has a caste pride in himself, and a sincere religious horror, even sometimes a condescending pity, for the Bourgeois caste—a feeling exactly the same and about as strong as that with which the monocled and lorgnetted stalls at Covent Garden before the war would have greeted the intrusion of a dinner jacket—a complete social and moral ostracism. I shall never forget the gasp of consternation, sudden and general from the passers-by, that greeted me when, one Sunday evening on the old Kominavstrovsky I bent down to pet the ridiculous pet dog of two plump promenading Bourgeois, nor the glow of gratitude on the faces of the man and his wife, that someone had, even indirectly, noticed their human presence.

Bourgeois Will Out.

Now, while the Intellectuals have, in virtue of the theoretic ethical propriety of their professions, a public honour and status of the highest degree, yet in their concrete personal contact with proletarians they are all tarred in varying degree, with the suspicion of being Bourgeois. Actors and actresses are invariably mentioned with the resounding and glorious title of "People's Artist of the Republic So-and-So." Savants are treated with a newspaper deference (people's universities, people's professors), comparable to the exaggerated importance accorded by Frenchmen to an academician. Yet every Worker knows that the unregenerate Bourgeois Adam lurks beneath, waiting his chance to show his original top-hatted snobbish sin. All the younger scientists, and many of the

senior, wear the Russian blouse characteristic of workpeople and offices, but I have seen one die-hard Herpetologist who arrived steadfastly at the Museum every morning in aged morning suit, round-handled umbrella, and a bowler hat with two dents in it.

Tamed Scientists.

Of course, this is not unnatural. All the pure scientists of to-day are by training, habit, and family, snobbishly disdainful of the working class and the "Workers' Republic." There is a charming elder scientist who retains uninterrupted a finely appointed flat in his ancestral home; pictures, sculptures, and carpets of jadis; who is in continued receipt of a pension begun by the late Tsar. He scrupulously refrains from the slightest political comment, devoting himself diligently and keenly to his work, but he naturally regrets that he does not still possess the whole building. Moscow scientists complain, "Look, we are dreadfully treated. Formerly we had this whole flat, now we have only two rooms." Since they are reduced, they are bound to feel injured, though it remains true that their two rooms are as much or more than the accommodation permitted to anyone else, save a handful of revolutionary heroes who have each a villa about the size of an English bank-clerk's. But though they may sigh, if not for the snows of yesteryear, at least for a next year a little different from to-day, there is in no single one of them the slightest counter-revolutionary hope or ardour. The Communist who said, "The scientists are Bourgeois, but quite tame," summarized accurately.

In the proletarian mistrust of them there is only one serious inconvenience. It is next to impossible for the children of scientists to secure admission to the universities and higher scholastic institutions. This is not due to any government regulation prohibiting their attendance, but to a combination of the following factors. In the first place certain scholarships and places at the schools and colleges are reserved for trade union and party nominees in much the same way as, in this country, a Cambridge college may have a number of scholarships reserved for candidates from Eton. In the second place, at various stages of education admission to a higher stage depends on the ability of the student to pass what is called a collective examination. This takes the form of a debate on his eligibility conducted by him and his fellow students, after which his admission is determined by vote, each student and each teacher voting once. This method works excellently, I am given to understand, in circumstances where only the cultural qualification of the student comes up for discussion; but where his caste is under suspicion, his fellows ruthlessly exclude him without possibility of appeal. The wastefulness of this method is thoroughly regrettable (although, it must be admitted, Intellectuals' children do, sometimes, reach the universities, and their number is doubtless at least as great, proportionately, as the number of workers' children who reach English universities). When I deplored it, I received this reply, "It is certainly a pity, doubtless it will be attended to. We are so busy, and many tasks are more urgent. Come back later; if it is still so, your complaint will be just. At present, remember, we have only been going eight years." The situation is perhaps aggravated by the not unnatural tendency of scientist parents to restrain their infants from joining the "Pioneers," or Communist Boy Scouts. The glamour and very real delights of this body would elsewise no doubt attract them, as it does all other towns-children, and solve the difficulty in a generation by making them trusted little Communists by the time they reach university age.

The Banquet.

In September of this year took place the bicentenary of the Academy of Sciences. The celebrations brilliantly illustrated this curious incongruity, the scientist honoured and privileged by the Workers' Republic as the cultural leader of the working class, and yet himself slipping back at each opportunity to Bourgeois forms. For this bicentenary the Academy was permitted to invite whomsoever it chose, from all parts of the world, save only Rumania and Bulgaria, anathema because of the White Terror—and Switzerland, unforgiven for the Vorovsky murder. The baggage of the delegates was scarcely touched at the frontier, either coming or going. Every delegate, foreign and Russian, was royally feted; reduced prices, special opera and ballet, visits to the Kremlin, public banquets were arranged for him. And the great Soviet officials, from Kalenin, delighted to honour the event with special orations. Moreover, the salaries of many scientists were raised for the occasion. Yet, with this means, the leading ones rushed to equip themselves with evening dress, seeing no better purpose than to linger nothing behind the Bourgeois respectabilities of the visitors. And the less prosperous contrived to buy pasteboards, which they pathetically wrote out as neat visiting cards. A gesture vain yet something beautiful.

been possible to fill in the gap from other sources, and the whole length of post-glacial time is now found to be 8,500 years*. By studying the layers in temporary lakes formed during the retreat of the ice across southern Sweden and comparing different sections, it has been found that the ice vacated central Scania 13,500 years ago and set free the site of Stockholm 10,000 years ago. After the end of the Ice Age there were several minor fluctuations of climate, but the ice did not again occupy the site of Lake Ragunda.

Other Areas.

In the Alps the classical researches of Penck and Brückner† indicated that the recession of the glaciers after the last or Würmian maximum was interrupted by three halts or slight re-advances, termed the Bühl, Gschnitz and Daun stadia. Correlation of the glacial stages in the Alps and in northern Europe is very difficult, but it seems probable that the Bühl and Gschnitz stadia correspond with halts in the recession of the Scandinavian ice-sheet. The Gschnitz stadium was followed by a long period of warm dry climate, and the Daun stadium falls definitely within the post-glacial period. Penck and Brückner dated it at 5000 B.C., but recently Gams and Nordhagen‡—an ideal combination of a Swiss and a Norwegian geologist—have produced good evidence that it occurred during the early Iron Age, and they date it as late as 850 B.C. In other parts of the world the full history of the final recession of the ice-sheets is not yet known, but a great deal is at present being done in North America, especially by de Geer's method of the annual clay layers, and it seems probable that the stages of retreat were the same there as in Scandinavia.

All round the coast of Scandinavia and the Baltic, on the moraines left by the retreating glaciers, there is evidence in the form of beaches and other marine deposits that during and after the close of the ice-age the sea stood much above its present level, and the fossils in these marine deposits tell a remarkable story of the changing climate. For the present we will confine our attention to the Baltic. At first, while the ice was retiring across southern Sweden, this sea stood but little above its present level. The straits leading to the Atlantic were still blocked by ice, and between the ice in the north and the coast to the south was an intensely cold fresh-water lake, on which icebergs floated. Then the ice vacated southern Sweden and Atlantic water flowed in, but the Baltic was still intensely cold and the characteristic fossil is the northern mollusc *Yoldia arctica*. This brings us to the end of the Ice Age. In the northern parts of the Baltic the land continued to sink relative to the sea, but in the south-west there was a slight rise, which again closed the connection with the Atlantic. The characteristic fossil in the deposits of this period is the fresh-water mussel *Ancylus*. Then followed a great submergence; in the Gulf of Bothnia beaches formed during this period are now at heights of more than 300 feet. The distribution of the mollusca shows that the Baltic was warmer and more saline than now, indicating a broader connection with the Atlantic; this is known as the *Litorina* sea. Since then there has been a gradual change to present conditions.

A post-glacial rise of sea-level, generally by about ten feet, and often accompanied by a fauna indicating a slightly warmer climate than the present, occurred in many other parts of the world—Franz Josef Land, Spitsbergen, Iceland, Greenland, Northern Ireland, the east coast of North America, Patagonia and Tierra del Fuego, South Africa, south-east Australia and Antarctica. Such a general uniform change indicates a rise in the level of the sea rather than a sinking of the land—of this more later.

Peat-bog Evidence.

The third line of evidence is derived from a study of the peat bogs, and is exceptionally complete owing to the economic value of peat. A typical section through a south Scandinavian bog is shown in Figure 1. The lowest layer (*a*) consists of fluvio-glacial sands. Above this is a thin bed of mud with rushes and sub-arctic plants (*b*), followed by a layer of tree-stumps, mainly birch, but with some oak (*c*). Then comes a thick layer of peat (*d*), followed by a second layer of tree-stumps (*e*), representing a mixed forest in which the oak predominated. Finally we have a second thick layer of *Sphagnum* peat (*f*), dried and weathered at the top. The obvious interpretation of this sequence is that after a short cold period the climate became sufficiently dry and warm in summer for a birch forest to grow. Then followed a wet period in which peat killed the forests, followed by a second splendidly dry and warm period in which rich forests were able to grow even on the dried-up surface of the bogs. Again the climate deteriorated, and the forests died. In the last few centuries there has again been a turn for the better. This sequence

* Antevs, Ernst. "Swedish Late-Quaternary geochronologies." *Geogr.. Rev.*, New York, N.Y., 15, 1925, p. 280.
† Penck, A., and E. Brückner. "Die Alpen in Eiszeitalter." Three volumes. Leipzig, 1901-09.
‡ Gams, H., and R. Nordhagen. "Postglaziale Klimaänderungen und Erdkrustenbewegungen in Mitteleuropa." München Geogr. Gesellsch., Landesk, Forschungen, H. 25, 1923.

From the Ice Age to the Iron Age.

By C. E. P. Brooks, M.Sc.

Few things have greater interest to archaeologists than those which touch on the early developments of man. The study of post-glacial climatology is slowly building up for us a picture of the succession of changes which influenced evolution. How the dates are estimated is explained in this article.

It is curious that for many years we have known less about the geology of the period which lies immediately before us than about remote geological ages. While the distribution of minute subdivisions of, for instance the Jurassic was mapped with meticulous care, the post-glacial deposits were generally lumped together as "recent," and regarded as encumbrances on the face of the earth, which interfered with the study of the real rocks. There were, of course, exceptions, such as the late J. Geikie's brilliant studies of the superficial deposits of Scotland, but it is only within the present century that post-glacial geology has become a recognized branch of the science. Its home was in Scandinavia, which—for long ages a land-mass and finally swept bare by a great ice-sheet—has practically no deposits intermediate in age between Archaean and Pleistocene, or between the oldest and youngest, and it was at the International Geological Congress at Stockholm in 1910 that the wealth of incident in the post-glacial period was first brought prominently before the geological world. The special volume published by that Congress* brought together the views of a large number of geologists in all parts of the world, but some of these views were obviously hasty and ill-considered, betraying the authors' recent acquaintance with the subject. The impetus once given, much careful work has been done, and it is now becoming possible to write the climatic history of the post-glacial period with some approach to confidence.

Basis of Study.

Let us consider the materials available for this history. First, and most important as providing a framework for the whole, we have the moraines marking the recession of the last ice-sheets, and indicating climatic fluctuations by the alternation of long halts with periods of rapid retreat. Next in importance we have the raised beaches and other indications of the varying levels of land and sea; these also by their fossils indicate changes of climate. On land we have a varied assortment of superficial deposits—peat bogs, deposits of lakes, calcareous springs, sand dunes. Somewhat vaguer in their indications, but still capable of yielding important evidence, are an assortment of facts about the distribution of animals and plants. In America we have the rate of growth of trees during the past four thousand years, providing a wonderful series of indications as to fluctuations of rainfall, paralleled in the Old World by a mass of somewhat doubtful archaeological evidence as to the habitability of various semi-arid regions. In short, almost any fact on almost any subject which dates from the past twenty thousand years or so may throw light on some aspect of post-glacial climatology. Within the limits of a short article it is impossible to describe this vast mass of evidence in any detail; one can only refer to a few salient points.

An Exact Date.

We may regard the Ice Age as a great war waged by the malignant forces of Nature upon the plants and animals of that period. Four times the ice issued from its fastnesses in Scandinavia, the Alps, and various other centres, and invaded the surrounding settled country, only to retreat after causing great devastation. After the final retreat hostilities did not end abruptly at the same time on all fronts, but as it is convenient to have a fixed point, Swedish geologists have decided upon the stage at which the remnant of the great Scandinavian ice-sheet split into two detached portions as marking the official end of the Ice Age and the beginning of post-glacial time, and this will make a convenient starting-point for our study. Fortunately we know its date with some accuracy, and the manner of our knowing is almost a romance. The final retirement of the ice set free a basin in central Sweden which was immediately occupied by Lake Ragunda, and since then the still waters of this lake have been receiving year by year the drainage of a small mountain glacier. Each year a thin layer of mud was deposited, but owing to the seasonal variation in the rate of melting, each year's deposit was divided into a light and a dark layer, giving a banded clay. This lake was accidentally drained in 1796, and de Geer has counted the number of layers formed during the existence of the lake. The uppermost layers had been destroyed, but it has

* Bericht International Geologenkongress, Stockholm, 1910. "Die Veränderungen des Klimas seit der Maximum des letzten Eiszeits."

than Persian times. The general result of the Asiatic evidence is that the course of climatic changes in Asia was closely similar to that in Europe. Finally a brief reference must be made to North America. A. E. Douglass discovered that in the dry climate of Arizona and southern California the rate of growth of trees, indicated by the width of the annual rings, shows close agreement with the amount of rainfall. Some of the big trees (*Sequoia*) still living came into existence four thousand years ago, giving us a unique rainfall record. About 200 measurements of tree-growth were collected by Ellsworth Huntington,* who constructed from them a well-known curve of climatic change. The rate of growth of a tree differs at different ages quite apart from climatic factors; a young tree grows more rapidly than an old tree, and there are other difficulties, but a recent publication of the Carnegie Institution of Washington† enables us to calibrate the curve of tree-growth. Close to the region of the big trees there are a number of salt lakes, which show evidence in the form of beaches of having at one time been at a higher level. L. Claude Jones has discussed the history of these lakes in detail, estimating the date at which they began their present existence as enclosed lakes from the ratio between the amount of salt in the waters of the lakes and that carried in by the rivers feeding them. He finds that the age of Lakes Pyramid and Winnemucca is between 2,500 and 3,000 years; since they have apparently never overflowed, this means that previous to 500 or 1000 B.C. they must have been dry for a long period. Owens Lake, on the other hand, became fresh rather more than 2,000 years ago because its waters rose to such a level that they overflowed the basin. Similarly Walker Lake indicates a period of high water about 900 years ago. The beaches in the lakes also show the levels during a number of stages of high water which can be arranged in chronological order, and this series of lake levels permits us to correct the curve of tree-growth.

For North Africa rainfall curves are provided by the records of the Nile floods, which depend on the rainfall in Abyssinia, and by the level of the low-water stage, which depends on the rainfall of equatorial Africa. From these various sources I have constructed a series of rainfall curves, which are shown in Figure 3. The period since the end of the Ice Age is divided into two parts; on the left the period from 6500 to 1500 B.C., for which we have only general information, is shown on a contracted scale; on the right the period from 1500 B.C. to the present day, for which more detailed information is available, has a more open scale. At the bottom of the diagram an attempt has been made to construct a curve of solar activity, based on the frequency of records of sunspots and aurorae. A comparison of the curves brings out three features. In the first place there is a long-period swing, the curves being mostly low until 850 B.C.,

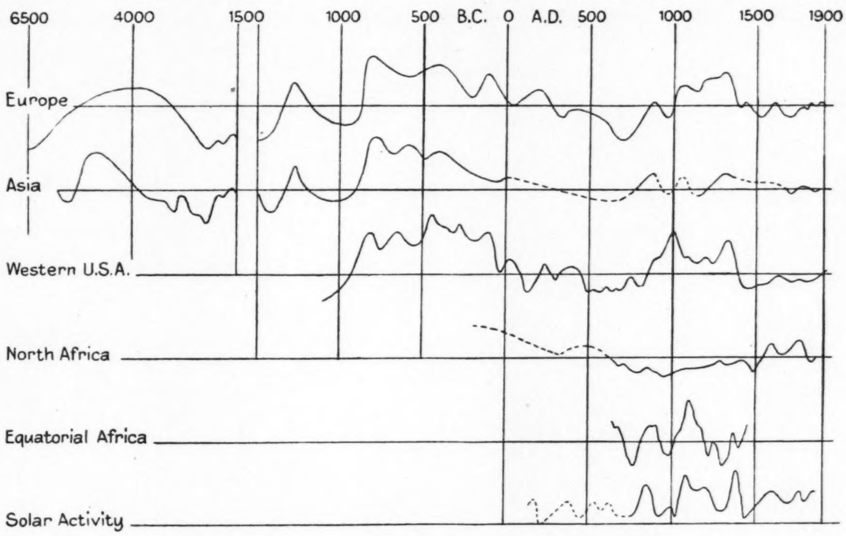


FIG. 3.
VARIATIONS OF RAINFALL AND SOLAR ACTIVITY.

* Huntington, E. "The climatic factor as illustrated in arid America." Washington, Carnegie Institution, 1914.

† Washington, Carnegie Institution. "Quaternary climates." Papers by L. Claude Jones, Ernst Antevs and Ellsworth Huntington. July, 1925.

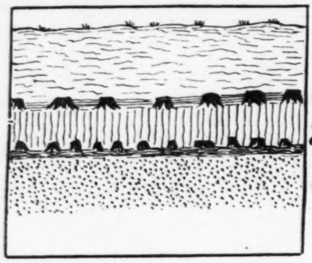


FIG. 1.
GENERALIZED SECTION THROUGH A SCANDINAVIAN PEAT BOG.

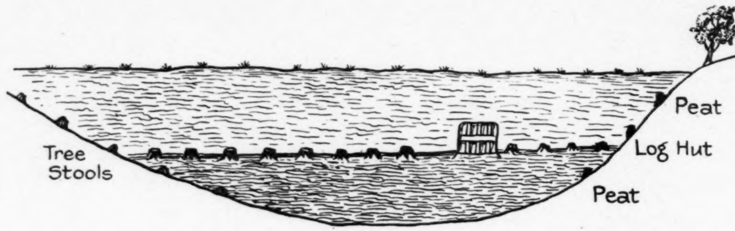


FIG. 2.
DIAGRAMMATIC SECTION THROUGH DRUMKELIN BOG.

was discovered in 1876 by the Norwegian, Axel Blytt, who devised the nomenclature: Boreal (the first dry period), Atlantic, sub-Boreal, sub-Atlantic. It is true that the sequence has been explained also by the mechanics of water supply in a peat bog, but the phenomena are so general over wide areas, and fit in so well with other types of evidence, that there is no doubt that the climatic explanation is the correct one. On land which emerged from the sea after the Boreal period was over the sequence did not begin at the beginning; only one forest layer is present, which can be recognized as the sub-Boreal, and this fact enables us to correlate the peat-bog sequence with the changes of level. The peat-bog sequence is confirmed by the deposits of calcareous springs, many of which dried up during the Boreal and sub-Boreal periods and became very active in the Atlantic and sub-Atlantic. The fluctuations of small lakes tell a similar story. When all this evidence is considered together it will be seen that the post-glacial fluctuations of climate in northern Europe have been proved over and over again. Perhaps the most remarkable point in the story is that the genius of Axel Blytt made out all this sequence from the details of the distribution of living animals and plants alone, and he merely went to the raised beaches and the peat bogs to confirm his views.

Primitive Man.

The great peat bogs of Ireland show a generally similar sequence, but without the sub-arctic bed (Figure 2); the layer (*e*) is especially interesting, for its rich archaeological remains dating from the late Neolithic and Bronze Ages. During the growth of the lower peat layer, Neolithic man lived on the sand dunes, but in the very dry sub-Boreal period he migrated to the dried surface of the peat bogs. A two-story log house has been discovered in Drumkelin Bog*. In the following wet period the settlement was smothered by the bog and the roof of the hut is covered by twelve feet of peat.

Climatic Changes.

The archaeological evidence in Europe is not so simple as the geological, but it is of great importance in dating the great change from the genial sub-Boreal to the cold wet sub-Atlantic. The data come from Switzerland, and are briefly as follows: During the Bronze Age and the beginning of the early Iron Age (Hallstatt A) the products of Mediterranean civilization penetrated freely into Switzerland across the Alpine passes. At the same time agriculture in the Alps extended to considerably above its present limits. Early in the Hallstatt B period there was something in the nature of a catastrophe; the mountain settlements were abandoned, not only the cultivated fields but even the mines for salt and metalliferous ores. During the succeeding centuries the Iron Age settlements were limited to a few of the warmest and driest valleys, which developed independently without outside influence. The beginning of Hallstatt B was very near 900 B.C., so that the climatic collapse which began the sub-Atlantic period must have occurred about 850 B.C. This period was marked by such a definite re-advance of the Alpine glaciers that Gams and Nordhagen consider with much justification that it must be identified with the Daun stadium of Penck and Brückner's scheme.

Our knowledge of climatic changes in Asia at present depends almost entirely on much-debated archaeological evidence. Here it will be sufficient to quote the history of the semi-arid settlement of Anau in the north of Persia. This site was first occupied about 9000 B.C., and abandoned soon after 6000 B.C. after a period of gradually increasing drought. The next settlement began about 5200 B.C., and continued until about 2200 B.C., with a short interruption probably due to drought in 3000 B.C. The drought of 2200 B.C. was very severe, and the site was not again occupied until the Iron Age, not much earlier

* Mudge, William. "Description of an ancient structure dug out of Drumkelin Bog, in the Parish of Inver, County of Donegal, in the year 1833." Archaeologia, 26, 1836, p. 361.

then high until about A.D. 260, low again until A.D. 1000, and subsequently high. Secondly, superposed on this slow swing are a number of minor variations which are substantially the same on all the curves, including that of solar activity. The third point is that the amplitude of the long-period fluctuations increases northward, while that of the short-period fluctuations diminishes. Hence we infer that while the minor fluctuations are due to direct solar influence, and are therefore greatest at the equator, the changes of longer period are due to some cause which is centred in high latitudes. This cause can only be Arctic Ice.

Ice and Sun Spots.

It is well known that the greater part of the Arctic Ocean is covered by a floating mass of ice, of which only the fringes break up in summer. The temperature of the air above this ice is very low—near the North Pole it is about —30° F. in January—but recent calculations* have shown that this low temperature is almost entirely produced by the ice. If the ice could be swept away the mean temperature even in mid-winter would be about 27°F. Let us call this the "akryogenous" (iceless) temperature. If the ocean were free of ice and the akryogenous temperature were only 5°F. higher than at present, the Arctic Ocean would not freeze. When an ice-cap has once been formed, its mere presence suffices to lower the actual temperature by some 50°F., and this makes it very stable, and able to survive minor changes of climate, just as it survives the seasonal change from winter to summer. Hence to sweep it away the akryogenous temperature must be well above 28°F. (the freezing point of sea water) for a number of years. This happened during the sub-Boreal period. Even between about A.D. 260 and 1200 the ice conditions were much less severe than they are now. During the latter part of this period the Norsemen were colonizing Greenland, and Pettersson† has pointed out that their records contain very little reference to floating ice.

On these lines we may write the history of the post-glacial period as follows: The Ice Age ended about 6500 B.C., but it left the Arctic Ocean filled with floating ice. About 4000 B.C. depression of the North Atlantic regions let a flood of warm water into the Arctic Ocean, which swept away this ice-cap, and a period of dry climate set in, with moderate winters and hot summers. The oceans warmed up, this and the melting back of the ice-sheets beyond their present limits raised the general sea-level, and the Climatic Optimum about 1500 B.C. is marked in almost all parts of the world by beaches about ten feet above the present beaches. About 850 B.C. the supply of heat fell off for some reason, and the Arctic Ocean again became glacial. After 100 B.C. the Arctic ice-cap gradually broke up, although, except possibly for a short time in the seventh century, it did not entirely vanish. The final stage set in about A.D. 1000 with a second renewal of the ice-cap, associated quite definitely this time with an increase in the sun's spottedness, and this stage has continued to the present day.

* Brooks, C. E. P. "The Problem of mild polar climates." London, *Quarterly Journal of the Royal Meteorological Society*, 51, 1925.

† Pettersson, O. "Climatic variations in historic and prehistoric time." Svenska Hydrogr.-Biol. Komm. Skrifter Heft 5.

Books Received.

Journal of the Photomicrographic Society. Vol. XIII. Published September, 1925. (Non-Members, 7*s*. 6*d*.).

Annual Report of the Smithsonian Institution. 1923.

The Facts of Psychic Science and Philosophy. By A. CAMPBELL HOLMS. (Kegan Paul. 25*s*. net).

The Personal Equation. By LOUIS BERMAN, M.D. (George Allen & Unwin Ltd. 8*s*. 6*d*. net).

The Surface History of the Earth. By JOHN JOLY, Sc.D., F.R.S. (Oxford University Press. 8*s*. 6*d*. net).

The Dinoflagellates of Northern Seas. By MARIE V. LEBOUR, D.Sc., F.Z.S. (Marine Biological Association of the United Kingdom. 12*s*. 6*d*. net).

Determination of the Exact Size and Orientation of the Great Pyramid of Giza. By J. H. COLE, B.A. (Cantab), F.R.G.S. Survey of Egypt Paper No. 39. (Government Publications Office, Cairo. P.T. 10).

Journal of the Marine Biological Association of the United Kingdom. Vol. XIII. No. 4. Issued October, 1925. (The Association. 8*s*. net).

British Mosquitoes and their Control. By F. W. EDWARDS and S. P. JAMES, M.D. Economic Series No. 4a. (Printed by the Trustees of the British Museum. 6*d*.).

Soil Characteristics. By PAUL EMERSON, Ph.D. (McGraw-Hill Book Co. Inc. 12*s*. 6*d*. net).

The House of Health. By SIR JOHN ROBERTSON, C.M.G., O.B.E., M.D., B.Sc. (Faber & Gwyer Ltd. The Scientific Press. 2*s*. 6*d*. net).

Nursing in the Home. By STELLA CHURCHILL, M.R.C.S., L.R.C.P. (Faber & Gwyer Ltd. The Scientific Press. 2*s*. 6*d*. net).

The Fight against Infection. By LIEUT.-COL. G. E. F. STAMMERS, R.A.M.C. (retired) (Faber & Gwyer Ltd. The Scientific Press. 2*s*. 6*d*. net).

Zoologie im Grundriß von Dr. Walter Stempell. 1 and 2. (Gebruder Borntraeger. 1 G.M.6.60. 2. G.M.6.90).

The Mathematical Theory of Electricity and Magnetism. Fifth Edition. By J. H. JEANS, D.Sc., LL.D., F.R.S. (Cambridge University Press. 21*s*. net).

Pygmalion, or the Doctor of the Future. By R. MCNAIR WILSON, M.B., Ch.B. (Kegan Paul. 2*s*. 6*d*. net).

Stage-lighting for "Little" Theatres. By C. HAROLD RIDGE, A.R.S.M., D.I.C., etc. (Heffer & Sons Ltd. 5*s*. net).

Three Centuries of Chemistry. By IRVINE MASSON, M.B.E., D.Sc., F.I.C. (Ernest Benn Ltd. 10*s*. 6*d*. net).

"Linaludo": Instruction Book and Sketch Books. No. 1 and 2. By ARCHIBALD SHARPE, B.Sc., A.M.I.C.E., F.C.I.P.A. (E. Marlborough & Co. Ltd. Cloth, 4*s*. small set).

Elementary Qualitative and Volumetric Analysis. By F. H. CAMPBELL, D.Sc., F.A.C.I. (Macmillan & Co. 6*s*. 6*d*. net).

Enemies of Timber: Dry Rot and the Death-Watch Beetle. By ERNEST G. BLAKE, M.R.S.I. (Chapman & Hall Ltd. 12*s*. 6*d*. net).

A number of other books received will be acknowledged in the next issue but are temporarily held up owing to pressure on space.

Rhizopoda with Shells.

By Sir Arthur E. Shipley, G.B.E., F.R.S.

A number of different species and sub-species of these interesting animals are known, but much has yet to be found out about the life history of the opaque shelled forms.

JUST one hundred and fifty years ago Rösel von Rosenhof* saw sticking on the side of a glass vessel of water and weed a particle of jelly, the movements of which attracted his attention. "It fastened itself," he writes, "on the side of the glass and since, like animals, it moves, although very slowly, from place to place, and thereby continually alters its form, and as I frequently examined the water with a magnifying-glass, the creature was necessarily discovered and, as soon as I touched it, it contracted itself into a sphere and fell to the bottom." Rösel removed the specimen to a watch-glass, and observed it continually changing its shape. In consequence of this peculiarity, he named the animal "the small *Proteus*" after the monster of fable. This monster was an old Greek sea-god, called by Homer the "Old Man of the Sea." He knew all things, past, present, and future, but was reluctant to reveal his knowledge. First of all you had to catch him, but he eluded capture by assuming all sorts of shapes such as those of a lion, serpent, leopard, bear, tree, and even fire and water. But if you could only hold him long enough he came back to his original shape, and revealed his secrets.

Amoeba in General.

As the name *Proteus* was preoccupied it was changed to *Amoeba,* and *Amoeba proteus* is one of the commonest kinds we find in our fresh-water pools. Cash has estimated that there were some nine or ten distinct species of this genus in the fresh waters of our country, though some of these are regarded as sub-species. They are, as we have said in a previous article, usually found in the mud at the bottom of ponds, or creeping about on the algae or water-plants. But certain rare forms are found in the sphagnum moss so common in the bogs of Ireland. *A. proteus* throws out finger-shaped pseudopodia, and may have one or more nuclei. *Amoeba guttula* is a common enough species of very small size; its pseudopodia are hardly noticeable. On the other hand *A. limax* seems to have a definite anterior end towards which it moves, and as the protoplasm flows forward the cuticle of the hinder end becomes thrown into fan-like ridges as if it were elastic. Many other species are found in the sea, but their validity and their life-history are still matters of considerable anxiety to the systematist and the morphologist. Some *Amoebae,* which are now generally grouped under the generic name of *Endamoebae,* live in the alimentary canal of many animals. One, *Endamoeba coli,* is almost universal in man and apparently does little harm, though *E. histolytica* is the cause of a very active tropical form of dysentery and was one of the most troublesome diseases to deal with during the late war. A particularly large form allied to *Amoeba* organisms is *Pelomyxa,* and when we are hunting the bottom of ponds or ditches we may have the luck to come across specimens of this. At times it attains a length of two to eight mm., and is easily visible to the naked eye. It has an innumerable number of minute nuclei, perhaps as many as 10,000, besides which there are scattered particles of nuclear material known as chromidia.

* August Johann Rösel von Rosenhof was the author of four volumes on "Insects" which he published between the years 1746 and 1761. He also published a "Natural History of Frogs" at Nuremburg in the year 1758, and a further four volumes on "Insects" in the years 1764-1768.

Thalamophora.

All these forms are entirely naked—except for the thinnest transparent cuticle—and absolutely unashamed. They are grouped together in one of the three great classes of protozoa, the Rhizopoda, and this class is characterized by the absence of a definite covering and the presence of the power of emitting pseudopodia. The class is divided into six groups, of which the *Amoeboidea* are naked forms devoid of a shell. But a second order, which is called *Thalamophora,* have a very definite shell of a very definite composition. We will now turn our attention for a moment to some of these *Thalamophora* with their different kinds of shells. There is a little form called *Arcella* with a circular shell, which is again found amongst the mud and weeds of our pools and ponds and lakes. The shell is shaped something like a Chinese labourer's hat or a watch glass with a cover. In the centre of the cover is a circular opening known as the pylome. The bulk of the protoplasm is contained within the shell, but through the shell opening or pylome a few pseudopodia project and aid the little creature to creep about. The shell is the product of the secretion of the organism. It is at first colourless and

apparently consists of a horny or chitinous material which is marked all over with minute hexagons. As the animal grows older the shell enlarges by the intercalation of new hexagons between the old ones; it also thickens and becomes brown, which is the characteristic colour of *Arcellas*. The shell is believed to consist of chitin, a chemical substance found frequently in the animal kingdom; and it is thought by some authorities that this substance is allied to uric acid. The most obvious examples of chitin are the hard cases which envelop the bodies of insects, spiders and myriapods, like plate-armour. The shell is at first transparent and through it can be detected two nuclei and a number of gas bubbles which were at one time thought to contain carbon-dioxide, but are now believed to contain oxygen. To some extent, undoubtedly, they act as floats and help to keep the animal the right side up. There are two primary nuclei and a scattered amount of nuclear material which is known as chromidium.

British Species.

Reproduction in *Arcella* is like reproduction in *Amoeba*, by division. A large part of the protoplasm emerges from the shell and at the same time each of the two nuclei divides into two, and two of the four resultant nuclei pass into the outside mass, which then separates away and forms the body of a new *Arcella*. But there is a second method of reproduction. At times both the nuclei disappear and then the protoplasm of the body balls itself up round the minute chromidia which act as secondary nuclei. Each of these units now constitutes a spore, and one by one they leave the shell and shortly develop stiff pseudopodia. After a time these spores conjugate in pairs and each pair, now termed a zygote—for it is the result of the fusion of two reproductive bodies—grows up into a young *Arcella*. This is one of the simplest forms of sexual reproduction we know.

According to a Ray Society monograph published by James Cash in 1905 on the Fresh-water Rhizopods the following species of *Arcella* occur in Great Britain:

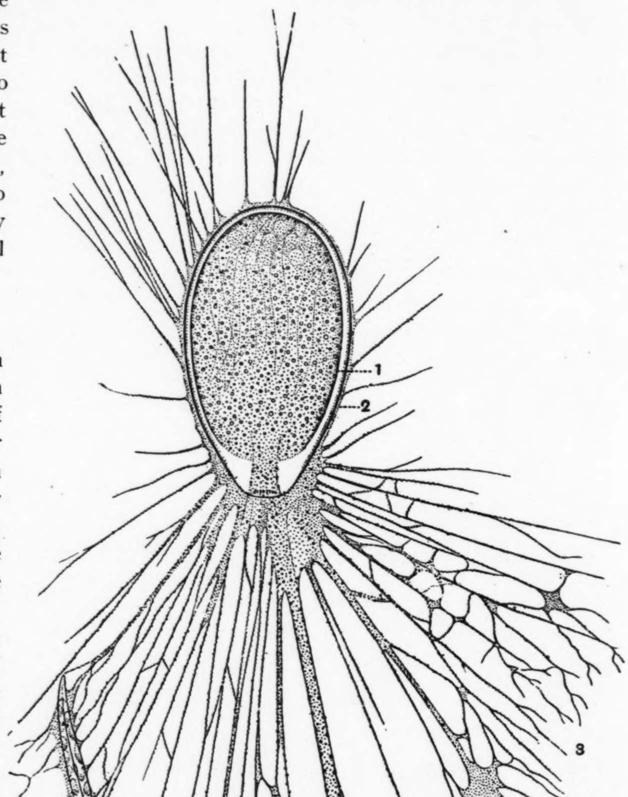
(1) *Arcella vulgaris*, which is almost hemispherical in side view. This is found in ponds and ditches and is very generally distributed.

(2) *A. discoides*, which has a somewhat flattened shell. This is less common than *A. vulgaris*, but is frequently found in ponds and marshes.

(3) *A. mitrata*. The shell is balloon-shaped. It has been found amongst moss and Utricularia in Yorkshire and in North Wales.

(4) *A. dentata*, a rather doubtful inhabitant of our country. It is characterized by spikes protruding from the edge of shell. Specimens very like it have been found by Cash.

(5) *A. artocrea*. The shell is pitted and covered with small dome-like protuberances. Owing to the presence of chlorophyll corpuscles in the protoplasm it is coloured a bright green. This form has been taken in North Wales and in Co. Donegal.



GROMIA OVIFORMIS x 250
but the Pseudopodia are less than one-third their relative natural length.
(*From M. S. Schultze.*)
1. Shell. 2. Protoplasm surrounding shell. 3. Pseudopodia, fusing together in places, and surrounding food particles such as diatoms.

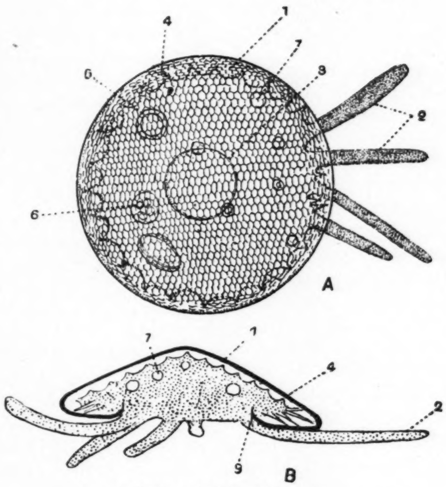
In a later volume by the same author and G. H. Wailes the following are included :

(6) *A. catinus.* This has a number of pores surrounding the central aperture or pylome, usually about a dozen. It is rare in our islands, though not uncommon in America.

(7) *A. arenaria,* with two nuclei and very numerous contractile vacuoles. This form occurs amongst mosses and is widely distributed in Great Britain and Ireland.

(8) *A. polypora,* with from six to twenty small nuclei and many contractile vacuoles. This has been found sporadically living amongst sphagnum and other fresh-water vegetation.

In certain specimens of *Arcella* a small organism has been observed living in the protoplasm. This has been christened *Nucleophaga,* but little or nothing is known about it.



ARCELLA DISCOIDES, x 500.
(*From Leidy.*)
A. Seen from above. B. Seen from the side, optical section. 1. Shell. 2. Pseudopodia. 3. Edge of opening into shell. 4. Thread attaching animal to inner surface of shell. 5. Nucleus. 6. Food vacuole. 7. Gas vacuole.

Gromia.

A very interesting case of one of the Rhizopods with a shell is afforded by *Gromia,* a small aquatic organism of singular beauty. The shell is thin and membranous and shaped something like an egg with the pylome at one end. It differs from many others inasmuch as the shell is immersed both inside and out in protoplasm, there being a thin protoplasmic layer embracing the whole of the outside of the shell. Again the pseudopodia, which arise most copiously near the pylome, but also emerge from the outer layer of protoplasm, are in all cases thin, delicate threads which at times unite together and form little congrescences of protoplasm in which the food particles such as diatoms are embedded. The thin, almost straight, pseudopodia entangle amongst themselves the living food particles and then proceed to accumulate protoplasm round them which digest the food outside the main part of the body. The digested food is then conveyed along the pseudopodia into the interior. The shell is uniform and shows no markings, but allied forms such as *Quadrula* have reticulated shells. In the last-named genus each shell is made up of a number of quadrilateral areas continuous with one another and secreted by the body. The shell of *Gromia* is flexible and appears to stretch as the animal grows.

An even more interesting case is presented by those members of the *Thalamophora* which build up their shells of extraneous matter. A good example of this is *Difflugia,* shaped like a pointed egg with the blunt end cut off. The blunt end forms a pylome and from it stretch out a number of finger-shaped pseudopodia which may or may not show a series of granules. But the interesting thing about *Difflugia* and its allies is that they possess a selective power. They pick and choose the substances with which they build up their shell, as a builder picks and chooses bricks as he is building up the shell of a house. No doubt in some cases the selection is governed by the material at hand. The constituents at the bottom of the water are what they have to work on. In some cases these are intermingled, and you may find sand granules, the flinty skeletons of diatoms, the siliceous spicules of sponges, all welded together into a common shell. In other cases the selection is complete. One genus will use nothing but sponge spicules, another will weave a felt of sponge spicules covered on the outside by fine particles of sand. Then again the size of the material selected differs from one animal to another. Some will use fine and some will use coarse material. But the selective power is so considerable that it is used as a specific characteristic. Occasionally shells of their dead neighbours are used and the whole is welded together by a cement which may be firm or flexible and may consist of chitin, ferric oxide, or calcium carbonate.

Selective Arrangement.

It must further be noted that all these extraneous particles are not casually caught up in a sticky secretion, but are deliberately and of full purpose definitely arranged in position by the animal which has first selected them from their surroundings. As a rule *Difflugia* has only one nucleus. The chromidia or small particles of nuclear matter in *Difflugia* are united to form a fine network which envelops the nucleus or the nuclei, but in *Arcella* the nuclei are surrounded by a halo of perfectly clear protoplasm.

(*Continued on page 447.*)

Book Reviews.

The Spectroscopy of X-rays. By MANNE SIEGBAHN, Professor of the University of Upsala. Translated by GEORGE A. LINDSAY. (Humphrey Milford: Oxford University Press. 20*s.* net).

The physics of X-rays is one of the most important branches of modern work in the realm of atomic structure. X-ray spectroscopy is yielding astonishing results in the hands of workers all over the world, and the English translation of Professor Siegbahn's work comes as an invaluable assistance to a wide range of workers. It is undoubtedly the most complete work yet published, and may be said to initiate the new era of precise determinations of X-ray spectrographic measurements.

One of the most useful sections of the work deals exhaustively with the technique and apparatus employed by the author as well as that used by other workers. The development of the new types of precision X-ray spectrometers is traceable step by step, and a wealth of diagrams and illustrations record this latest chapter in the development of instruments.

Emission spectra and absorption spectra are fully and exhaustively treated, but the author specifically omits both the work of Compton on the scattering of X-rays and the recent work of Duane on abnormal reflection. The book may, however, be taken as covering the full scope of the subject in all its accepted applications up to the beginning of the current year. Work is proceeding so rapidly in this field that no work of this nature can pretend to be other than a milestone marking the point reached at a given period.

Spectroscopists and physicists will find the excellent series of tables invaluable. These have been amended and brought up to date, and now comprise the most readily accessible reference index of lines available. This important book is essentially one for the specialist and the advanced worker, but apart from its essential value in this respect it may well become the standard work of reference on the subject. The translation is exceptionally able and the book is singularly free from passages where an unfamiliar construction tends to obscure the sense.

The Surface History of the Earth. By JOHN JOLY, Sc.D., F.R.S., Fellow of Trinity College, Dublin. (Humphrey Milford: Oxford University Press. 8*s.* 6*d.* net).

Professor Joly has long been known as the author of a new theory of geological evolution which ranks as one of the most important ideas of our time. In general it may be expressed as the idea that our land masses or continents and our oceans are floating on an internal core of basalt rock comprising the vast mass of the globe. This basalt or magma contains distributed through its texture a proportion of radioactive material which slowly generates heat for which there is no escape. In the course of some thirty to forty million years so much heat will be generated that the basalt will be melted, and then a vast geological cataclysm will inevitably occur and floods of molten basalt will overflow the face of the earth or escape into the ocean beds. This uncomfortable theory is unpleasantly confirmed by almost everything we know about geological history. There have been terrific periods of activity in the past, and it is evident that these have been successive.

It was not until the modern discovery of radio-activity of rocks that a clue was found which could explain these successive geological revolutions. Radio-activity coupled with the knowledge we now have of Isostasy (the condition under which the land masses float on and displace the underlying magma) affords a complete explanation of the past and an ominous portent for the extremely remote future.

The theory also gives us new light on the formation of the mountain masses and the great rifts. In the past too much stress has been laid on lateral compressional or folding movements. In the light of Professor Joly's theory it is easier to explain the lifting of the mountain masses by vertical thrusts from below exerted by the cooling magma.

Much confirmation of the estimates of the age of the various cataclysmic epochs is afforded by the study of circular spots in mica from early rocks. These spots surround a central invisible point of radio-active material, and it is the rays from these minute enclosures acting for millions of years which have produced these remarkable discs or haloes.

The rate of decomposition of radio-active materials is known, and, working from this probable age, estimates can be evolved. Precision is not yet attainable, as it appears probable that in some cases unknown radio-active materials may have been formed in the breaking-down process, and that these in turn developed unknown rays or energies which may have altered the relative graduation of the circles in the mica spots.

The book is written in simple straightforward language, and is astonishingly interesting. A glossary is included which will be a useful help to readers whose knowledge of geological terms is slight. It can be heartily recommended for making accessible to the layman what are practically the latest important ideas in this particular branch of knowledge.

Perseus or of Dragons. By H. F. SCOTT STOKES, M.A. (Kegan Paul. 2*s.* 6*d.* net).

This little book is included in the same series as "Daedalus," "Icarus," "The Mongol in our Midst," and other books which have all had something to say and said it remarkably well. This book lowers the standard of the series badly. It may sell on its title, but so far as giving any coherent account of dragons is concerned, it reminds one of the young entomologist who spent half-a-crown on "Hints to Young Mothers." But for the M.A. after the author's name we should have said undergraduate. As it is there is nothing even moderately sympathetic that can be said.

The Dinoflagellates of Northern Seas. By MARIE V. LEBOUR, D.Sc., F.Z.S. (Published by the Marine Biological Association, The Laboratory, Citadel Hill, Plymouth. 12*s.* 6*d.* net).

Not only professional zoologists but naturalists and microscopists will welcome this extremely useful book. One of the great handicaps of the individual worker is the difficulty of identifying organisms. All too often the literature is sparse and difficult of access, or it may be in an unfamiliar language or buried in the files of extinct scientific papers. Dr. Lebour here presents us with an astonishingly complete and beautifully illustrated guide to the Dinoflagellates. It is not easy for anyone who has not done systematic work with the microscope to realize what endless hours of study and detail work have gone to the making of this book, both in its completeness of text and the wonderful series of drawings. The fruits of these labours are admirably presented, and the price of the book is low enough to make it available to all keen students and societies. It is very definitely a book to buy and study, for a great deal of work still remains to be done on these organisms, and studies by workers on the coasts or near estuaries may be extremely fruitful.

Dinoflagellates are the microscopic organisms which often

give the peculiar colour to shallow waters in estuaries or even to patches of the open sea. They present a wide variety of types, and vary in size from dwarfs of seven microns to giants nearly two millimetres large. It is probable that further investigation may show that some species are really larval forms of others, and the life histories of many species require careful investigation.

Collecting methods are simple, and a silk tow-net of 180 strands to the inch is used. The examination of the catch is best conducted at once and with live material, and presents neither serious difficulties nor does it call for expensive or extensive apparatus.

Dr. Lebour's book covers some four or five hundred varieties belonging to the group and its morphological sub-divisions. The great proportion of the drawings are from live specimens and by the author; a minority, in cases where specimens were not available, are from previous works by other writers.

An excellent and clearly-expressed introduction tells us something—but all too little—about Dinoflagellates in general, their habits, foods and the localities where they may be expected, but the author stresses the point that the study of Dinoflagellates is still in its infancy and that discussion is for the time being outside the scope of this particular book.

Here then is a work which will bring endless interest and pleasure to those who care to add to the store of their scientific knowledge about the fauna of our seas. It is to be hoped that it will stimulate the activities of many workers, for with this book to hand the study of this particular form of marine and estuary fauna becomes immediately practicable and within the compass of the amateur as well as the professional.

By Airplane towards the North Pole. W. MITTELHOLZER and others. pp. 176. Illustrations and Maps. (London: G. Allen & Unwin Ltd., 1925. 10*s.* 6*d.* net).

In the summer of 1923 Amundsen hoped to fly from Alaska to Spitsbergen across the Pole. With a view to aiding him in this task the Hammer expedition was to attempt to place depots of food and petrol on the pack-ice north of Spitsbergen, using for the purpose a Junker's aeroplane. Amundsen, finding that his machine was unfit for the journey, did not start, and thus the Hammer supporting expedition was saved from what promised to be a fiasco. Even if Amundsen could have found the depots on the moving ice, it is extremely improbable that he could have picked them up. But Mr. Hammer and Lieut. Mittelholzer, being already on their way north, decided to use the opportunity in gaining experience of flying in Spitsbergen. After a few preliminary essays a long flight was taken over northern Spitsbergen. An accident then happened to the seaplane and the expedition returned to Europe. This is not a wide experience on which to base a volume which could not be justified were it not for the record of the first adventure of its kind in Spitsbergen. But the title is misleading; no attempt was made to fly towards the North Pole. The book is a composite production in which Lieut. Mittelholzer of the Swiss Air Force describes the features of the expedition and the actual flights. Prof. A. Miethe, who was not with the expedition, has a useful chapter on air photography, and Prof. K. Wegener contributes a general introduction on the geography and history of Spitsbergen. Prof. Wegener alone had had previous Arctic experience, having wintered at the German meteorological observatory in Cross Bay, Spitsbergen, in 1912-13. His introduction is not altogether satisfactory. On the physical side it is best, but even there mistakes occur, unless the faults lie in the translator's lack of acquaintance with technical terms, *e.g.*, in regard to pack-ice. The assumption of the truth of the Wegener hypothesis of continental displacement may be the outcome of family loyalty, but is apt to be misleading. In the economic and historical sections several mistakes occur. There never was, in recent times, any suggestion that Spitsbergen should go to Denmark. Norwegian suzerainty was established in 1925. The records on mining should have been revised in the light of recent history. There is no British tax upon coal exported from Great Britain. Lastly, the authors seem to be unaware that their amendments (which are not published) to the map of Gypsum Bay and Gypsum Quarter (their own names for the Bünsow land region) were not required, since the region was re-mapped in detail by Mr. J. Mathieson in 1919. The old chart to which they refer was already obsolete In fact the volume, which first appeared in Germany, bears evidence of hurried preparation and somewhat deficient knowledge in the sphere which it attempts to cover, but it gives a graphic account of Arctic flying and is illustrated by a large number of unique and beautifully reproduced air photographs. The translators evidently forgot to translate into English the German spelling of Spitsbergen. There is no index.

R. N. R. B.

The Lost Oases. By A. M. HASSANEIN BEY, F.R.G.S. (Thornton Butterworth. 21*s.* net).

The author, an Arab who was educated at Oxford University, takes us from Sollum, on the Mediterranean, to El Obeid in the Sudan. His expedition was of great geographical value, for its achieved object was the rediscovery of the lost oases of Arkenu and Ouenat, the very existence of which was only a vague tradition. The strictly scientific element of the book is, however, relegated to the appendices, and the story here set forth has all the glamour of a traveller's true tale of the unknown. Oxonian and Egyptian Mussulman, patriot and diplomat, proud of his many English friendships, yet sensitively responsive to the call of the desert, the writer was eminently fitted by both temperament and circumstance to interpret this region and its inhabitants to the British reader. The large leisure, the peace and simplicity of those who live in lonely places is charmingly reflected in this record of an expedition which was carried out under the protection of the Senussi and with the assistance and support of King Fouad.

We learn from it the real truth about such things as sandstorms, mirages, and wells, about the Bedouin attitude to camels, and the Arabs' hostility to strangers. Touches of humour add a last charm to this extraordinarily vivid and informing narrative of an expedition, the results of which, as Sir Rennell Rodd remarks in his introduction, have enabled the author "to fill in an important gap in our knowledge of Africa."

A valuable appendix is given at the end of the book which deals with the astronomical determination of local time in the Libyan Desert, Determinations of Latitude, Compass Variations, a Summary of Principal Geographical Positions and Levels, together with geographical data hitherto unpublished in any book on that part of Africa traversed by the author.

Some of the observations taken by Hassanein Bey are of enormous interest and may shortly revolutionize surveying maps—such as they are at present—dealing with the country from Durna on the Mediterranean to the oasis of Kufra in the Libyan Desert. For instance, from observations made at the oasis of Jalo the Bey discovered that the level of Jalo is sixty metres higher to-day than it was when Rohlfs ascertained it

in 1879. "He found," says the author, "Jalo almost exactly at sea-level; I found it sixty metres higher. I saw the explanation of it going on before my eyes. The drifting sands were climbing slowly up the trunks of the palm trees and against the walls of the houses, threatening to engulf them. Some of the inhabitants had already moved their houses and rebuilt them on higher levels. It is the steadily accumulating sand, driven by sandstorms and gathering wherever trees and houses stop its progress, that has raised Jalo nearly 200 feet above sea-level in forty-four years. The house I was living in, and at which the barometric readings were recorded, was from fifteen to twenty metres higher than the rest of the houses at Jalo."

This book is one which should be read not only by geologists with technical pleasure, but by the ordinary public with great interest, for it is the history of desert travel written by a man with a dual viewpoint—that of the Oxford scholar and that of the Bedouin in the desert.

On the Chemistry of the Ancient Assyrians. By R. Campbell Thompson, M.A., D.Litt., F.S.A. (Luzac & Co. 25*s*.).

In some ways the title of this book is a little misleading, for it suggests that it deals with ancient Assyrian theories on the structure of matter, whereas really it is a treatise on certain branches of applied chemistry, namely, glassmaking, minerals, and pigments.

There is in the British Museum a series of Assyrian Cuneiform Tablets of the seventh century B.C., which give not only minute directions for the preparation of frits, glasses, and enamels, but also details of the colouring pigments added to them. Hitherto many of the substances referred to in these working formulae have not been identified, and the difficult task which the author has set himself has been to discover what they actually were. The method he has used has been to get back to first principles, by comparing modern chemical processes (*e.g.*, of glassmaking), with ancient traditional methods, and then to draw tentative conclusions as to the substances which would probably be meant by Assyrian words used in the same connection. Next, from reasons based on the philological and etymological connections of these words with other Assyrian words or with Hebraic or Babylonian words (sometimes admittedly speculative) confirmative evidence is derived. And finally, it is shown that the formula thus worked out would be one that would give the desired result in practice.

As an instance of this etymological method, the ingenious identification of the Assyrian words AS.*HAR* with arsenic (p. 45) may be cited. Medical texts support the view that these terms signify arsenic, a substance used for the eyes. The same base AS has also been found to indicate a plant, which the author concluded on several grounds to be asafoetida. Since *HAR* equals esenu, "smell," AS.*HAR* suggests the idea of a foetid-smelling mineral substance, and, as is well-known, many arsenic compounds when burned emit a pronounced garlic-like odour. Similar reasoning is applied to some of the other arsenic compounds. Apart from the actual chemical analysis of the products themselves, this literary method affords the best, if not the only, means of gaining an idea of the chemical processes which had been evolved in Assyria.

It would be difficult to overestimate the immense amount of research required before the author could bring together all the results here published, or to praise too highly the logical way in which he collates his evidence and puts forward his conclusions. A full bibliography and good indexes of English, Assyrian, Hebraic and Syriac terms are appended. Naturally the subject is not one for light reading, but the book will be invaluable as a work of reference to future students of the development of applied chemistry and to Assyriologists. The author may also be congratulated on having not only written the book, but also produced it by mechanical means, for it consists of 158 clearly stencilled pages, with which are bound up six pages of the printed Cuneiform Texts. This is a method of production which might be more generally adopted for the publication of other abstruse works for which, owing to their specialized nature, the demand is likely to be limited.

C. A. M.

Time, Taste and Furniture. By John Gloag. (Grant Richards. 12*s*. 6*d*. net).

The archaeologist is nearly always limited in his survey of Roman Britain to architectural remains, pottery, coins and weapons. It is still a matter for regret that the average child's history-book gives such a false impression of Roman Britain as a land of woad-painted savages dominated by a handful of Roman engineers. Mr. Gloag suggests that comfortable furniture was a commonplace in Roman Britain, and that it is wrong to date the rise of furniture from the fourteenth century. It vanished during the Dark Ages, but he quotes Mr. Collingwood, F.S.A., in support of the original "period" of English furniture. "The better villas of the Romanized British gentry were far in advance of anything that the Middle Ages could show, and were equal to the finest Elizabethan and Jacobean mansions in everything but their baths, in which they immeasurably outstripped not only them but all their successors down to the present day."

The book is divided into three admirable sections, the first dealing with the historical evolution of furniture and the quality and variety of furniture woods. An extremely useful chapter on the wiles of the faker will prove of the utmost utility to the collectors who think that they know something about furniture. There is wisdom to be gleaned here. The second section deals with the beginning of the revival after the decline of the early Victorian era and leads us from Morris to "modern" furniture and the foundation of the "D.I.A."—Design and Industries Association—which endeavours not unsuccessfully to induce manufacturers to apply modern designs rather than turn out an endless stream of indifferent "period" manufactures.

It is not everyone who will find the modern work to his or her liking, for it is more a matter of harmonious and appropriate design than any direct break-away from convention. Possibly it awaits the genius of a coming twentieth-century Chippendale to bring to it real life. In general Mr. Gloag's book is the best authoritative summary of the state of the furniture craft of to-day as well as in the past. The book is well and abundantly illustrated, and should appeal to all who are interested in furniture and decoration in their relation to the applied arts.

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